MEASURING COGNITIVE LOAD: A META-ANALYSIS

OF LOAD MEASUREMENT SENSITIVITY

by

Jeffrey L. Hodson

A thesis submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Master of Science

Department of Educational Psychology

The University of Utah

May 2016

The University of Utah Graduate School

STATEMENT OF THESIS APPROVAL

The thesis of **Jeffrey L. Hodson**

has been approved by the following supervisory committee members:

Robert Zhiwei Zheng	, Chair	**08/07/2015** Date Approved
Anne E. Cook	, Member	**08/07/2015** Date Approved
Sharlene Akemi Kiuhara	, Member	**08/07/2015** Date Approved

and by **Anne E. Cook** , Chair/Dean of

the Department/College/School of **Educational Psychology**

and by David B. Kieda, Dean of The Graduate School.

ABSTRACT

The current study utilized a meta-analysis review to investigate the sensitivity of several cognitive load measures. Specifically, the study examined whether self-rating, single-task performance, dual-task performance, eye-track, or physiological measures are most sensitive to changes in cognitive load. Additionally, the sensitivity of load measures was analyzed in relation to several variables such as age, research design, and learning content. After the initial search, 224 publications were identified and coded for inclusion in the meta-analysis. A random-effects model was employed, and the results demonstrated that cognitive load sensitivity varied by measure type. The load sensitivity among the study characteristics of age, content area, and research design also varied corresponding to specific cognitive load measure types. The number of self-rating items used to assess cognitive load did not significantly vary between single item and multiple item scales. Lastly, cognitive load sensitivity did not vary significantly among the measures in relation to peak and overall load. The last result may be biased by a small sample size of peak measures *($n = 8$)*.

To my amazing and wonderful wife Morgan, thank you for your love, support, and patience throughout this journey. Onward and upward to many more adventures together.

CONTENTS

Appendices

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

To Dr. Robert Zheng, I am especially grateful for your flexibility, patience, expertise, and constant support throughout this project. I also would like to thank Dr. Anne Cook and Dr. Sharlene Kiuhara for their input, consideration, efforts, knowledge, and assistance.

CHAPTER I

INTRODUCTION

Sweller and Chandler (1991) argue that there is only one true goal of any theory of cognition and instruction, which is, "the generation of new, useful instructional techniques" (p. 351). Since the 1980s, cognitive load theory has brought about multiple principles of learning that have directly impacted the practices of instructional design. It has also served as the foundation for various approaches of technology integration such as multimedia with instruction.

The particular interest to this study is the measurement of cognitive load. Over the years, many researchers have measured cognitive load for a variety of purposes and areas of interest. The diversity for which cognitive load measures have been used, including topics such as pilot flight training, adaptive learning systems, foreign language learning, and computer design training, speaks well to its value. However, as Cook, Zheng, and Blaz (2009, p. 2) point out, "…the central question pertaining to the study of cognitive load still remains unanswered: When, how, and at what level do we know the learner is cognitively overloaded? In other words, how do we define cognitive load, and how do we measure it…?"

A number of measures have been designed with the hopes of identifying cognitive overload more accurately and reliably. As of yet, it is still not entirely clear how sensitive each measure is to specific changes in cognitive load. It is also unclear how each measure maps to specific facets of cognitive load (Cook, Zheng, & Blaz, 2009).

A particular area of concern is that traditional measures have only provided a static, cumulative analysis of cognitive load (Beckmann, 2010). Such measures are useful for relative comparisons of task difficulty, yet fail to diagnose when and where difficulty occurs during the instructional task. This issue is amplified by the complex nature of the learning process, which often requires a learner to manage several cognitive elements and make multiple decisions. Consequently, mental demands are likely to fluctuate as decisions are made and various cognitive elements interact (Cook, Zheng, & Blaz, 2009; Xie & Salvendy, 2000).

Thus, static measures are unfit to analyze the dynamic constructs of cognitive load. To address this limitation, Xie and Salvendy (2000) proposed a framework which included dynamic constructs such as instantaneous load, peak load, and accumulated load. In order to identify these specific constructs of load during a learning task, the measures used must correspond to static or dynamic constructs.

Cook et al. (2009) took this framework a step further in proposing a convergent approach to cognitive load measurement which combines multiple measures in hopes of obtaining a more holistic view. A convergent approach that includes both dynamic and static measures may reveal when and where the source of cognitive load occurs. Furthermore, both instructional design and especially remediation of overload may be facilitated by answering the question of when and where load occurs.

Leppink, Paas, van Gog, van der Vleuten, and van Merriënboer (2014) further suggest that "the use of multiple indicators for each of the separate types of cognitive load might yield a more precise measurement and might enable researchers to separate the types of cognitive load more clearly than the use of a single indicator for each scale" (p. 33). However, without verifying the sensitivity of each measure to specific load constructs, it is impossible for a researcher to know if the measures employed are appropriate for the intended constructs. Consequently, research needs to be conducted to investigate the sensitivity of each measure (Cook, Zheng, & Blaz, 2009). The following section will outline how the current study intends to investigate the issues listed above.

The Current Study

Purpose

The goals of the current study are to investigate (1) the sensitivity of each of the cognitive measures to the type of cognitive load in learning, and (2) investigate the relationship between several cognitive load measures and related variables such as age, content area, and research design.

As mentioned previously, Cook, Zheng, and Blaz (2009) proposed a framework that describes the relationship between the types of cognitive load and measures (see also Zheng & Cook, 2012). In their framework, the authors identify five types of cognitive load measures and their mapping to ten different cognitive loads (Table 1). The current study employs the framework from Cook et al. (2009) to examine how sensitive each measure is to the cognitive load measured. Specifically, the study attempts to answer the questions of whether online measures differ from offline measures in terms of the types of cognitive load assessed, whether research design influences the sensitivity of load measures, and whether some measures are more effective and accurate than other measures in terms of the content area and age. Thus, it is hypothesized that the sensitivity of the types of cognitive load measured may vary depending on content area,

Table 1. Mapping construct definitions of cognitive load onto measurements of cognitive load.

Mapping construct definitions of cognitive load onto measurements of cognitive load (Cook et al, 2009)

	Includes:	*Subjective or objective?*	*Construct definitions of cognitive load:* *Mental load*	*Mental effort*	*Performance*	*Mental efficiency*	*Instantaneous load*	*Peak load*	*Accumulated load*	*Average load*	*Overall load*	*Attended content*
Analytical	Production systems	Subjective	•									
	Expert opinion	Subjective	•									
	Task analysis	Subjective	•									
	Mathematical models/ computer simulations	Subjective	•									
Rating	Rating scales	Subjective		•							•	
Task- and performance-based	Primary task measures	Objective		•	•	•						
	Navigation behaviours	Objective		•	•	•						•
	Secondary task measures	Objective		•	•	•	•					
Physiological	Heart rate	Objective		•			•	•	•	•		
	Measures of brain activity	Objective		•			•	•	•	•		
	TEPRs	Objective		•			•	•	•	•		
Other	Eye tracking measures	Objective		•			•	•	•	•		•

TEPRs, task-evoked pupillary responses.

age, and research design. The specific research questions and hypotheses are listed in the following section.

<u>Research Questions and Hypotheses</u>

Research Question 1: Which measures are most sensitive to changes in cognitive load? Hypothesis 1: The sensitivity of cognitive load measures will vary significantly.

Research Question 1a: Is there a difference in the types of cognitive load measures as indicated by the variance of effect sizes? Hypothesis 1a: There is a difference in the types of cognitive load measures as indicated by the variance in effect sizes.

Research Question 2: Is there a correlation between load measurement sensitivity and age, content area, research design, and/or offline/online measures?

- Hypothesis 2a: Load measurement sensitivity will vary by age.
- Hypothesis 2b: Load measurement sensitivity will vary by content area.
- Hypothesis 2c: Load measurement sensitivity will vary by research design.

- Hypothesis 2d: Load measurement sensitivity will vary by offline and online measures.

Research Question 3: Is there a difference in measurement sensitivity of self-rating scales that utilize a single item or multiple items? Hypothesis 3: There will be a significant difference in measurement sensitivity between self-rating scales that utilize a single item versus multiple items.

Research Question 4: Is there a significant difference between the sensitivity of peak load measures versus overall load measures? Hypothesis 4: There will be a significant difference between the sensitivity of peak load measures versus overall load measures.

Theoretical Framework

For any given instructional task, the learner must exert mental effort to obtain mastery. The expended mental effort places a load on limited working memory resources. Thus, cognitive load is the portion of working memory resources that is consumed while processing an instructional task. The primary aim of cognitive load theory has been to understand how to optimize the design of instruction. More specifically, cognitive load theory attempts to identify and correct situations where learners are mentally overburdened by task demands (Sweller, 1988).

The concept of cognitive overload is based on the premises of information processing theory (for an in-depth review, see Mayer, 2012), which maintains that working memory is severely limited while long-term memory is essentially limitless (Miller, 1956). As sensory information enters the working memory, it is processed and assimilated into long-term memory. Cognitive overload occurs when the number of elements required to be processed within working memory exceeds working memory capacity. In such instances of cognitive overload, a reduction of learning and performance occurs due to the portion of the instructional task that cannot be assimilated into a schema (Sweller, 1994; Cheon & Grant, 2012a).

Scope of the Study

The first step of the data process identified 349 research publications for potential inclusion in the meta-analysis. However, only 224 publications fit the final inclusion criteria (see Figure 1). Since each publication typically includes several experiments which involve different outcomes, these experiments were treated as separate analyses. For example, Deleeuw and Mayer (2008) used the dual-task method to assess cognitive load in the learning process. They conducted three experiments, all of which used dual-task method. Experiment 1 examined redundancy versus nonredundancy, $d = .53$; Experiment 2 examined low complexity versus high complexity, $d = .0659$; and Experiment 3 examined diagram versus text, $d = .1267$. They were listed as separate analyses. By treating each experiment independently, the database was expanded from 224 research publications to a total of 328 discrete experiments. Experimental studies also commonly reported multiple statistics of load measures. For the purpose of the meta-analysis, each effect size statistic is reported as a singular study. In total, 976 studies were coded from the database of 328 experiments.

The coding of the database revealed that adults were the most prevalent age demographic used in the experiments. However, other age demographics were also prevalent in the analysis. Three categories were used to organize the sample age demographics (see Table 2 for the number of included experiments reporting each

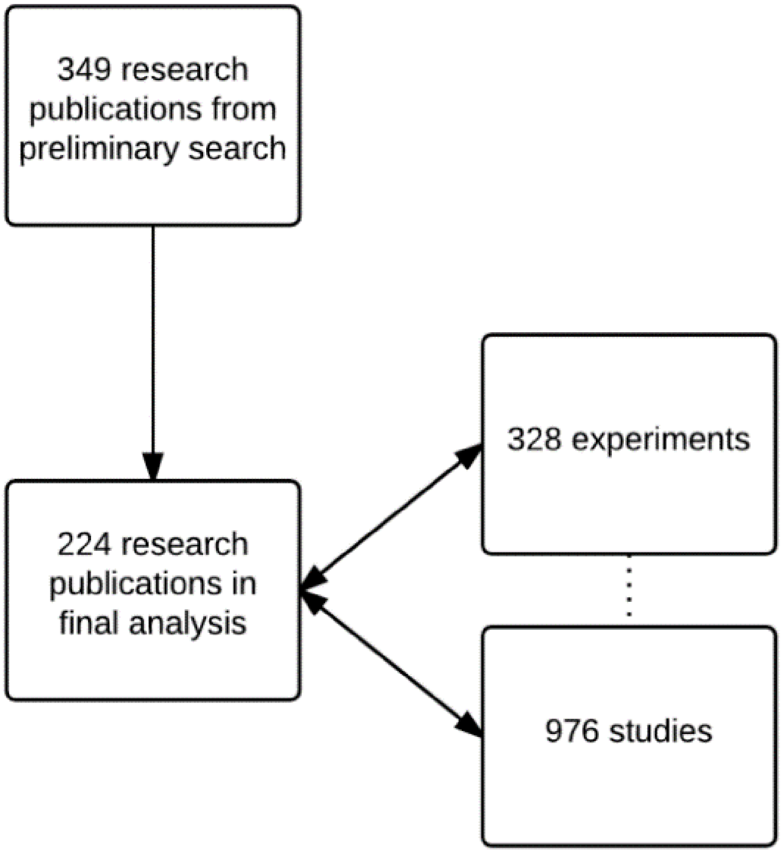

Figure 1. Number of publications, experiments, and studies included in the analysis.

Table 2. Demographics of research publications in the meta-analysis review.

Age	**Number of Experiments**
Grades 1-6	31
Grades 7-12	45
Adults	247
Not Reported	5
Total	328

demographic) which included elementary aged children (grades K-6), secondary school aged students (grades 7-12), and adults (ages 18 and over). The geographical regions where these experiments were performed included North America, Australia, and Europe. Next, the experiments in the study database encompassed five content area categories (science, mathematics, psychology tasks, liberal arts, and other). The science content area was defined as physical science subjects such as biology, physics, and anatomy. Mathematics content included subjects such as algebra, geometry, and arithmetic. The content area of psychology tasks contained experiments that investigated working memory and load through tasks such as N-back, visual search, and auditory tone tracking tasks. Liberal arts content consisted of subjects such as social sciences, language, and music. Lastly, experiments which used content that did not fit under the previous four categories were coded as "other". This category included content such as air traffic control, online learning, and computer programming.

The study also focuses on certain types of cognitive load. A portion of Xie and Salvendy's (2000) framework was investigated in the current study. Xie and Salvendy have suggested that "mental workload is incompletely defined…" The coding of the study database supported their assertion. Average, accumulated, and overall load measures were not sufficiently defined in the included publications to classify them separately. Each of these three cognitive load types result in a singular load outcome that spans an entire learning condition. Thus, average, accumulated, and overall load were classified as overall load for the purpose of the current study. The only other load measure identified during coding was peak load.

Definitions

In the current study, several variables are maintained to influence load measure sensitivity to some degree. Thus, the terminology of these variables is listed below.

Age

Age refers to the participant sample age. The demographics consisted of elementary-aged students (grades K-6), secondary school students (grades 7-12), and adults. Adults were participants over the age of 18. This included trade school, undergraduate, and graduate students.

Content area

Content area refers to the domain of the instructional materials used in the study. For example, several studies have utilized mathematics content such as algebraic bracket expansion problems to manipulate the level of cognitive load (Ayres, 2001; Ayres, 2006a; Kalyuga & Sweller, 2004). Other common areas of content include anatomy, biology, language, etc. In the absence of instructional materials, the type of task employed to study cognitive load (e.g., Stroop color task, air traffic control, etc.) was coded as the content area.

Online and offline measures

Each cognitive load measure was classified as either an online or offline measure. Online measures refer to measures that assess changes in load concurrently with the instructional task and that have the capability to detect dynamic changes of load within the task. In contrast, offline measures assess overall load after the task has occurred.

Number of self-rating items

Self-rating scales were classified by the number of items used to assess cognitive load. The number of items in self-rating scales refers to the number of questions for which a response is required of the participant.

Peak and overall load

As mentioned previously, the constructs of average, accumulated, and overall load were categorized as overall load. Average load is the total load experienced per time unit. Accumulated load is the total load experienced throughout a learning task. Overall load represents the participant's experienced load during the task. The current study also identified peak load during coding of the studies within the analysis. Peak load refers to the maximum load experienced at any single point within a task.

Research design

For the current study, research design means whether an experiment utilized a between-subjects design or within-subjects design to investigate cognitive load.

In summary, the current study attempts to help solidify which measures are sensitive to changes in cognitive load, and how measures are influenced by different variables. The next chapter will discuss the literature regarding cognitive load measures, the facets of cognitive load, and the variables affecting measurement sensitivity.

CHAPTER II

LITERATURE REVIEW

For any given instructional task, the learner must exert mental effort to obtain mastery. The expended mental effort places a load on limited working memory resources. Thus, cognitive load is the portion of working memory resources that is consumed while processing an instructional task. The primary aim of cognitive load theory has been to understand how to optimize the design of instruction. More specifically, cognitive load theory attempts to identify and correct situations where learners are mentally overburdened by task demands (Sweller, 1988).

The concept of cognitive overload is based on the premises of information processing theory (for an in-depth review, see Mayer, 2012), which maintains that working memory is severely limited while long-term memory is essentially limitless (Miller, 1956). As incoming information enters the working memory, it is processed and assimilated into long-term memory. Cognitive overload occurs when the number of elements required to be processed within working memory exceeds working memory capacity. In such instances of cognitive overload, a reduction of learning and performance occurs due to the portion of the instructional task that cannot be assimilated into a schema (Sweller, 1994; Cheon & Grant, 2012a).

Facets of Cognitive Load

Moving beyond the fundamental concept of overload proves difficult because cognitive load is multifaceted, and consequently, a complex concept to define. There is, however, a general agreement within cognitive load theory that there are three primary types of mental load: intrinsic, extraneous, and germane. These three loads are understood to be additive, each consuming a portion of the limited cognitive resources within working memory. What portion each occupies, depends on factors such as task complexity, instructional design, and individual differences (Sweller, 2010). Each of the three primary facets of cognitive load will be described below.

Intrinsic Cognitive Load

Intrinsic cognitive load is the mental effort required by a learner to process a task. Sweller, van Merriënboer, and Paas (1998) maintain that element interactivity is the source of intrinsic load. As the level of element interactivity increases, the required mental effort to process the task increases as well. Tasks with low element interactivity can be learned in isolation and therefore, consume less cognitive resources. Thus, low element interactivity tasks generally only become cognitively demanding when the sheer number of tasks to complete is surfeit. On the other hand, tasks that cannot be learned in isolation and that interact with other elements would impose a higher cognitive load (Ayres, 2006b).

Take learning the alphabet as an example, understanding the letter “A” does not require learning the letter “B.” The level of element interactivity is very low because they can be learned independently. When learning to read, a learner must understand how to pronounce combinations of letters. This requires the understanding of not only the individual letters, but the interactions between them. A learner would have to learn that the letter "C" is pronounced in a different manner depending on the letters that follow it (e.g., difference between *cat* and *center*). The increased element interaction results in additional information that needs to be assimilated, and therefore imposes a greater cognitive load.

In short, high intrinsic load results in a reduction of available cognitive resources in working memory which in turn affects the learner's performance in learning. So far, efforts have been made to reduce the intrinsic cognitive load through a two-step presentation approach by simplifying learning tasks with artificially isolated elements followed by instruction using the fully interacting elements to benefit low-knowledge learners (Lee, Plass, & Homer, 2006; Pollock, Chandler, & Sweller, 2002).

Extraneous Cognitive Load

Extraneous cognitive load is caused by the format and manner in which information is presented (Brünken, Plass, & Leutner, 2003). For example, teachers may unwittingly require students to mentally integrate mutually referring, disparate sources of information which exhausts the limited cognitive resources in working memory. The result is an increased cognitive load in learning. Chandler and Sweller (1991) examined the relationship between extraneous cognitive load and the split-attention effect by studying diagrams that were integrated with text and diagrams that were not. The results indicate that participants in the unintegrated condition performed poorly on the tasks and spent more time learning due to higher extraneous cognitive load. In contrast, those in the integrated condition outperformed their counterparts in both measures.

Germane Cognitive Load

The concept of germane load was initially introduced to cognitive load theory to separate useful, relevant learning demands on working memory from irrelevant and wasteful forms of cognitive processes (Sweller, van Merriënboer, & Paas, 1998). According to Sweller et al. (1998), germane cognitive load is the mental effort a learner applies toward schema construction in learning. It is associated with motivation-, attitude-mediated cognitive resources directed towards achieving learning objectives. When a learner attends to the learning elements, attempts to establish connections between them, and constructs a coherent mental representation in working memory, he or she invests germane mental effort.

Other Types of Cognitive Load

As noted previously, Xie and Salvendy (2000) assert that the traditional classification of cognitive load, that is, intrinsic, extraneous and germane cognitive load, is incomplete. They point out that the traditional classification of cognitive load implies a static degree of cognitive resources. Instead as they suggest, cognitive load should be considered as a dynamic construct reflecting the changes of cognitive load in learning. According to Xie and Salvendy, cognitive load can be further classified into instantaneous load, peak load, accumulated load, average load, and overall load.

Instantaneous load refers to the load that captures the fluctuations of mental effort over the time of learning. It best reflects the dynamic aspect of complex learning. *Accumulated load*, on the other hand, is the load that “builds up” over a task and is assumed to be the total amount of load experienced at task completion. *Peak load* indicates the maximum amount of load that the learner experienced during learning.

Average load refers to the mean degree or intensity of load experienced per unit of time. Finally, *overall load* refers to the learner's experienced load during the task.

In summary, the variability of cognitive load has necessitated the need to measure the various types of cognitive load in terms of their respective roles played within working memory. The following section discusses the status quo of cognitive load measurements in learning.

Measurements of Cognitive Load

Current measurement techniques assess cognitive load in an online or offline manner. Online measures evaluate the cognitive load experienced at the time of learning and are proposed to be capable of detecting dynamic changes of load within a given task. These measures include physiological methods such as eye-tracking, pupillometry, heart rate, and so forth, whereas offline measures include a priori and posteri-methods such as performance scores (Sweller, van Merriënboer, & Paas, 1998) and self-rating methods (Paas, 1992). It should also be noted, that certain measures (e.g., dual-task and performance) have both online and offline measurement outcomes. For example, performance measures have reaction time outcomes which would be classified as online measures, while accuracy scores would be considered offline (Cook, Zheng, Blaz, 2009). Next, the most common cognitive load measures are discussed below.

Analytical

The analytic method is a priori analysis that estimates cognitive load by referring to the levels of production in a given problem (Sweller, 1988). It is based on the assumption that cognitive load is correlated with the number of statements in working memory. Sweller (1988) noted that "human short-term memory is severely limited and any problem that requires a large number of items be stored in short-term memory may contribute to an excessive cognitive load" (p. 265). He thus argued that the number of productions and conditions in the task can serve as an effective estimate in measuring cognitive load in working memory.

The central issue of the analytical method is that it does not actually measure cognitive load empirically, but rather provides a subjective estimation of the mental workload to be exacted while processing a learning task. This method is described above for the sake of a comprehensive review. However, due to the absence of empirical measurement, the analytical method is not included in the current study for analysis.

Self-Rating

Self-rating measures require a learner to self-assess the task difficulty or the mental effort expended during the given instructional task. To implement this measure, learners simply rate their experienced cognitive load on a provided scale (Paas, 1992). Self-rating measures were the most widely used measure type in the current study. There are a number of factors that may explain the prevalence of these measures including the ease of use, cost-effectiveness, lack of intrusion into the given task, and prior results showing it to be a reliable measure (Paas, 1992; Joseph, 2014).

Self-ratings are, "…based on the assumption that people are able to introspect on their cognitive processes and to report the amount of mental effort expended" (Sweller, van Merriënboer, & Paas, 1998, p. 267). Although comparison has been made to validate the Paas rating scale (1992) with other similar scales such as the National Aeronautics and Space Administration Task Load Index (NASA-TLX), and evidence seems to suggest the sensitivity of self-rating to cognitive load measurement (Joseph, 2014), there is a significant debate on the use of self-rating scales as a valid and reliable measure for cognitive load (van Gog & Paas, 2008; van Gog, Kirschner, Kester, & Paas, 2012).

For instance, Ayres (2006b, as cited by Beckmann, 2010) found that a participant's level of expertise may influence self-ratings. More-experienced participants' task difficulty ratings were found to correlate better with actual performance scores than less-experienced participants. It appears that novice learners may not be as reliable and accurate in their ratings of task difficulty.

Performance

Performance measures are also widely used to evaluate the cognitive load in learning. This measure type focuses on error rates, learning time, and achievement scores to measure the cognitive load involved in learning (Joseph, 2014; Sweller, van Merriënboer, & Paas, 1998). Performance measures are based on the assumption that high-performance scores with less time spent in task performance provide a reliable measure for understanding the cognitive load in working memory (Tuovinen & Paas, 2004).

In order to provide more detailed data, performance measures have been used with subjective self-rating measures to evaluate multiple aspects of cognitive load in learning. This measure is referred to as an instructional efficiency score (Tuovinen & Paas, 2004). By combining the perceived cognitive load with the actual performance score, a new perspective is created that allows some insight into the effort required to produce a particular performance score. A performance measure on its own may not be able to evaluate load effectively when significant individual differences are present. For example, learners with similar scores may apply significantly different amounts of effort to obtain said score. Thus, efficiency scores may allow for a better examination delving deeper into the cognitive load experienced by the learner and examine where instructional interventions may be needed (Tuovinen & Paas, 2004; Paas & Merriënboer, 1993). However, the current study did not include efficiency performance scores due to time limitations.

Dual-Task

The dual-task measure evaluates learners' cognitive load by concurrently employing two tasks in learning which include a primary task and a secondary task. Schoor, Bannert, and Brünken (2012) point out the benefits of dual-task measures in that they are considered to be direct and objective, under the presumption that changes in dual-task performance are directly linked to cognitive load. Dual-task measures are based on the concept of limited working memory, and they are used to assess cognitive load by measuring performance variables such as reaction time and error rate pertaining to the secondary task. Increases of reaction times and error rates are seen as a reflection of increased cognitive load (Brünken, Plass, & Leutner, 2003).

Pupillometry and Eye-Tracking

Pupillometry seeks to measure cognitive load through the pupil diameter's physiological reaction to the instructional task. It is theorized that as cognitive load increases, the pupil would change its diameter size. Research indicates that the task complexity would cause measurable changes to the eyes as a given task is processed (for a more in-depth review of eye-tracking, see Rosch & Vogel-Walcutt, 2013). Changes in cognitive load are derived from assessment of variables such as the location of eye fixations, the number and length of fixations, saccade length (distance travelled between fixations), and saccade velocity. An increase in eye fixations and length of fixations is said to be related to higher cognitive load (Beatty, 1982).

A potential benefit of the eye-tracking and pupillometry measures is the ability to assess mental load without intruding greatly upon the instructional task itself (Antonenko, Paas, Grabner, & van Gog, 2010). However, environmental factors such as changes in luminance must be taken into consideration as potential confounding factors of pupil dilation (Tichon, Mavin, Wallis, Visser, & Riek, 2014; Porter, Troscianko, & Gilchrist, 2007). So, the assessments must be done in a controlled experimental setting that has not traditionally generalized well to authentic learning environments.

Physiology

Physiological measures assess cognitive load in an objective, unobtrusive, and direct manner. For the purposes of the current study, two types of physiological measures were included: heart rate and neuroimaging. Measures of heart rate can be further broken into mean heart rate and heart rate variability. Changes in mean heart rate during an instructional task are calculated in order to examine changes of cognitive load. Increases in mean heart rate are claimed to be associated with increases of cognitive load (Roscoe, 1993). However, certain concerns exist pertaining to mean heart rate measures. For instance, physical activity has the potential to artificially inflate workload measures during more rigorous tasks. Thus, care must be taken to avoid confounding results of workload. Roscoe (1993) also notes that mean heart rate measures are often criticized for lack of sensitivity to changes in load.

Heart rate variability may offer an alternative that is not subject to the limitations of mean heart rate measures. Measures of heart rate variability can be obtained by using an electrocardiogram (ECG) that measures R-R interval variability plotted as a function of time (Aasman, Mulder, & Mulder, 1987). Also, heart rate variability through spectral analysis of the three primary bands of frequency presents a more detailed approach than mean heart rate. The mid-frequency band, often referred to as the 0.10-Hz band, has been shown to systematically decrease as cognitive load increases. Vicente, Thornton, and Moray (1987) add that the mid-frequency band is preferable because of its capability to separate confounding variables such as, "…respiratory rate, motor activity and thermoregulation from the effort-related blood pressure component" (p. 175).

As stated previously, the second category of physiological measures included in the current study are neuroimaging measures. This approach assesses neural activity within the brain. Two specific measures were found while collecting publications: EEG and functional near-infrared spectroscopy (fNIRS). Antonenko, Paas, and Grabner (2010) maintain that neuroimaging measures such as EEG are truly online assessments of cognitive load in that neuroimaging is capable of continuously assessing cognitive load throughout the learning task, whereas other measures, such as dual-task, performance, or self-rating assess cognitive load periodically throughout the task or once after the task is completed. Continuous neuroimaging measures may allow cognitive overload to be identified in the specific moment it occurs. Such detailed analysis would certainly facilitate the remediation of overload.

Near-infrared spectroscopy (fNIRS) is the second neurological measure included in the current study. This measure requires the user to attach a set of sensors to the user's forehead. Durantin, Gagnon, Tremblay, and Dehais (2014) add that, "each optode records hemodynamics of the prefrontal cortex in terms of oxygenation level variations in comparison to a baseline." Thus, fNIRS can be employed in a within-subjects design, and similar to EEG it measures load continuously.

Attempts to Use Convergent and Dynamic Measures

There have been various attempts to measure specific facets of cognitive load. Yet, the results have not provided an overall consensus of which measures correspond to specific cognitive load constructs. Beckmann (2010) provided a synopsis of several experiments which are reported below.

First, Ayres (2006b) attempted to measure intrinsic load through self-rating measures. Ayres theorized that manipulating the complexity of algebraic problems while maintaining the same instructional design would keep extraneous and germane loads constant. Thus, any changes in reported load would be due to intrinsic load only. The results found self-rating measures to be sensitive to changes in intrinsic load. However, Beckmann pointed out that the results do not generalize well to other areas because individual differences, when not accounted for, can confound self-ratings.

DeLeeuw and Mayer (2008) also investigated facet-specific measures of cognitive load using science as the learning content area. Both self-rating and dual-task measures were included in their study in which they hypothesized that manipulating sentence complexity would represent a manipulation of intrinsic load. Yet, as Beckmann (2010) notes, it is difficult to distinguish between sentences that are needlessly or appropriately complex. Therefore, it is possible that what was identified as intrinsic load, may actually be extraneous load. More research is needed to confirm DeLeeuw and Mayer's results; this study hopes to provide further evidence toward confirming the sensitivity of load measures corresponding to specific constructs.

Variables Influencing Cognitive Load and Measurements

In addition to the issue of ambiguity in current load measures, there are certain variables that may also influence the sensitivity of each of the measures previously outlined. Consequently, the current study investigated the variables of age, content area, self-rating items, peak/overall load, and research design so as to evaluate the extent to which they are associated with each of the load measures. These particular variables may influence cognitive load measurement in diverse ways and are discussed below.

Age

Sample demographics were coded and included in the study. As mentioned in the scope of the study, three categories of demographics are used in the study: elementary school age (grades K-6), secondary school age (grades 7-12), and adults (age 18 and over). The adult age variable included various levels of education including trade school and university students (undergraduate and graduate). However, age and education could not be separated to examine individually due to the potential for confounding influence. Consequently, the adult education factor was subsumed into a singular variable of age.

Studies show that age plays a significant role in cognitive load research, particularly in the measurement of cognitive load. Van Gerven, Paas, van Merriënboer, and Schmidt (2006) used the self-rating measure to assess undergraduates' overall cognitive load and noticed a significant change over the time of the study (see also DiDomenico & Nussbaum, 2008, 2011; Paas, 1992). However, in van Loon-Hillen, van Gog, and Brand-Gruwel (2012), the authors used the same self-rating to measure fourth-grade students' overall cognitive load and failed to obtain similar results. Evidently, the sensitivity of cognitive load measures like self-rating is influenced by age. In other words, the self-rating measure is selectively sensitive to certain age demographics.

In addition to self-rating, it is believed that the effects of other cognitive load measures such as dual-task measures may vary by age (Jaeggi, Schmid, Buschkuehl, & Perrig, 2008). For example, Jaeggi et al. (2008) found demographic specific differences in a dual-task sequential N-back task. Jaeggi et al. used two separate modalities, visuospatial and auditory, and found no significant differences between undergraduate students and middle-aged adults when the groups completed each task separately. However, when the above groups processed both tasks simultaneously there was a decrease in performance by the middle-aged group.

Content Area

Content area, also referred to as learning domain, is another variable that is examined in the current study in order to see how measures may generalize to varied areas of content. For example, Schrader and Bastiaens (2012) studied the split-attention effect using physics content. Schrader and Bastiaens assessed the cognitive load experienced by the participants via a self-rating scale. Yet, no difference was found between the integrated helps and the separate helps conditions. Yeung (1999) also studied the split attention effect using a similar sample population as Schrader and Bastiaens, but the learning content of the study concerned reading comprehension for English language learners. Whereas Schrader and Bastiaens failed to find a significant difference using physics content, Yeung found a significant difference in the self-reported loads of integrated versus separated helps conditions. Given the equivocal results in cognitive load measures relating to age and learning content area, this study examines the sensitivity of cognitive load measures against age demographics and learning content area.

Research Design

Load sensitivity may also vary by the research methodology employed. The current study investigates whether the sensitivity of cognitive load measures differs when employing a within or between-groups research design, and whether the sensitivity of self-rating measures varies when using a single-item scale versus a multiple-item scale. First, specific load measures, such as self-ratings, commonly use either within- or between-groups research designs. However, physiological measures almost exclusively apply to within-groups research designs. The effects of using measures in either within- or between-groups designs seemingly has not previously been evaluated, and therefore, it is investigated in the current study.

Self-Rating Item Measures

Next, self-rating measures have traditionally used either a single-item assessment or a multiple-items assessment to evaluate cognitive load. Yet, it is not clear how this affects load measure sensitivity. For instance, two studies (Moreno & Valdez, 2005; Schmidt-Weigand & Scheiter, 2011) studied the effects of multimedia presentations about lightning formation on self-reported cognitive load. Undergraduate participants were used as sample population in both studies. In regard to the self-rating assessment, Moreno and Valdez utilized a single-item assessment which failed to find a significant difference in the multimedia conditions. In contrast, Schmidt-Weigand and Scheiter used a multiple-item assessment which found a significant difference in reported cognitive load. Thus, the number of items used in self-rating assessments may influence the sensitivity of load measurement.

Peak and Overall Load

The current study attempts to evaluate the load sensitivity of peak and overall load measures. According to Xie and Salvendy's (2000) framework of dynamic and static load measures, peak and overall load are proposed to assess discrete aspects of cognitive load. Specifically, peak load uses online measures assess the maximum cognitive load experienced at any single point during an instructional task. Overall load measures assess the cognitive load experienced by the learner over the course of the experimental condition.

Zheng and Cook (2012) studied the effects of graphic presentation in multiple rule-based problem solving. Their study utilized both overall and peak pupillometric measurement outcomes such as mean pupil size, the area under the curve of pupil size, and peak pupil size. All three outcomes were sensitive to load changes. However, their sensitivity varied: mean pupil size ($n^2 = 0.075$), area under the curve ($n^2 = 0.188$), and peak pupil size ($n^2 = 0.068$). In this case, the peak load measure was least sensitive, while the overall measures varied in their magnitude. Thus, in an effort to further investigate Xie and Salvendy's (2000) framework, the load sensitivity of peak and overall measures is included in the current analysis.

CHAPTER III

METHODS

Following the standard practice of meta-analysis, a code book was developed with criteria for inclusion of papers in the study (see Appendices III and IV). Three online databases (ERIC, PsycARTICLES, and PsycINFO) were used to identify relevant publications for the meta-analysis. Search terms such as "cognitive load measure," "cognitive load performance," and "cognitive load physiological" were used to find publications for potential inclusion (see Appendix I for the entire list of search terms).

The initial search identified 349 publications in cognitive load studies which served as the base for the study. However, not all of these publications were included in the analysis. After an in-depth review, only 224 publications were included in the final analysis. The following section will describe the inclusion criteria for the current study.

Data Processing

Inclusion Criteria

Time period of publications

The preliminary search for research publications included studies from 1981 to 2015 so as to obtain a comprehensive review of the body of research.

The nature of publications

Only peer-reviewed and published research articles utilizing experimental designs were included. This criterion required studies to utilize a baseline condition and an experimental condition. Any conceptual papers or reviews were not included in the analysis.

Statistical data

Each study was thoroughly examined in order to extract relevant, standardized effect size statistics (Cohen's *d*, partial η^2, etc.). When a study did not report the effect size of the treatment condition, sufficient data such as means and standard deviations must have been available to calculate the effect size.

Exclusion Criteria

The following exclusion criteria were used to make a decision pertaining to the exclusion of publications for final analysis.

1. Insufficient data. Studies that were excluded from the analysis due to insufficient data include: failure to report means and standard deviation, *F* or *t* values, and effect size.
2. Unpublished articles. Experiments that were not published (e.g., dissertations) were excluded.
3. Nonexperimental studies. Nonexperimental studies and conceptual papers were excluded from the analysis.
4. Correlational studies. Studies that only reported correlational relationships were excluded.
5. Noncognitive load measures. Studies that do not focus on cognitive load

measures were excluded.

6. Duplication. Studies that duplicate the previous studies were excluded.
7. Severe floor or ceiling effect. Studies that reported severe floor or ceiling effect were excluded from the analysis.

Of the 349 publications included in the preliminary database, 31 were excluded because of insufficient reported data. Thirty-three papers (including 30 dissertations) were excluded from analysis as they were not published or peer-reviewed. Twenty-two publications were excluded due to nonexperimental research designs including literature reviews and conceptual papers. An additional 18 publications reported only correlational data and were therefore also excluded from the analysis. The current study sought to examine load measures that are sufficiently established within the body of research. Any load measures that were not reported in at least five separate research publications in the database were excluded. For instance, additional eye-track measures such as saccade length and saccade velocity were scarcely reported and were therefore not included in the analysis. Ten publications failed to meet this criterion and were therefore excluded.

Next, nine publications that did not measure cognitive load were excluded. Another publication was a review of a publication already in the database. Thus, serving as a duplicate it was excluded. Finally, one publication reported severe ceiling and/or floor effects. The publication's findings concerning cognitive load were significantly skewed, and therefore unsuitable for the analysis. Table 3 provides an overview of the excluded publications.

Table 3. Number of publications excluded after initial data process.

Exclusion Criteria	**Total**
Insufficient data	31
Dissertations	30
Nonexperimental	22
Correlational	18
Insufficient publications using similar measure	10
Not measuring cognitive load	9
Not peer-reviewed	3
Duplicate	1
Severe floor or ceiling effects	1
Total	125

Preliminary Data Process

Once the publications were identified, they were organized into five measurement categories (dual task, performance, self-rating, eye-tracking, and physiological measures). Specific measures within each of the five categories were also identified and coded accordingly. For example, dual task measures were categorized as reaction time, accuracy, interval accuracy variability, and time to completion. See Table 4 for a complete list of the measures that were used to categorize the publications.

If more than one control condition was reported, the weighted average of the control conditions was used to calculate the effect size. When descriptive data (i.e., means and standard deviations) were the only available data in the experiment, the effect size was calculated using an online effect size calculator (http://www.lyonsmorris.com/lyons/metaAnalysis/index.cfm).

Table 4. Cognitive load measures included in the meta-analysis.

Performance	Dual-Task	Self-Rating	Eye Track	Physiology
1) Accuracy Score 2) Completion Time 3) Reaction Time	1) Reaction Time 2) Completion Time 3) Interval Error 4) Accuracy Score	1) Mental Effort 2) Task Difficulty 3) Workload 4) NASA-TLX	1) Fix. Duration[a] 2) Fix. Frequency[b] 3) Mean Pupil Size 4) Peak Pupil Size	1) Mean Heart Rate 2) HRV[c] – IBI[d] 3) HRV – LFB[e] 4) HRV – MFB[f] 5) HRV – HFB[g] 6) Systolic BP[h] 7) Diastolic BP 8) EEG[i] 9) fNIRS[j]

[a]Fixation Duration; [b]Fixation Frequency; [c]Heart Rate Variability; [d]Inter-beat Interval; [e]Low-Frequency Band; [f]Mid-Frequency Band; [g]High-Frequency Band; [h]Blood Pressure; [i]Electroencephalogram; [j]Functional near-infrared spectroscopy

Organization of Load Measure Outcomes

Performance measures and dual-task measures often use the same dependent variables such as reaction time, accuracy scores, error rate, and time to completion. In order to distinguish between performance measures and dual-task performance measures, the publication must explicitly state that it is a dual-task design. For example, dual-task experiments often employ vocabulary such as secondary or concurrent tasks. If no such explicit statement is present in its design, the study was reported as a performance measure of cognitive load.

Certain self-rating scales attempt to measure variables not directly associated with cognitive load such as anxiety, physical load, and time pressure. Therefore, self-rating scales included in the analysis must specifically measure variables directly associated with cognitive load such as task difficulty and mental effort. Self-rating scales were categorized according to how they explicitly inquire about the user's mental effort or the experienced task difficulty. This coding resulted in single-item scales being coded as either mental effort or task difficulty scales. In contrast, if multiple-item scales specifically inquire about both task difficulty and mental effort, then they were coded as workload scales. Consequently, each self-rating study was coded according to the number of items used to assess cognitive load in order to assess potential differences between multiple-item rating scales and single-item rating scales. Last, specific scales were found to have been used extensively throughout this review such as the NASA-TLX. This scale utilizes multiple items to obtain an overall score. Yet, some of the items such as physical load do not directly correspond to measures of mental load. Thus, NASA-TLX was coded as a separate category of self-rating measures for comparison of cognitive load sensitivity.

Eye-track and pupillometric measures were also coded. Eye-track measures evaluate gaze location while pupillometric measures assess changes in pupil size. For the current study, eye-track measures included fixation frequency and duration statistics, while pupillometric measures, on the other hand, included mean and peak pupil size.

Finally, physiological measures were organized into heart rate, heart rate variability, blood pressure, or neuroimaging measures. For heart rate and heart rate variability measures, mean heart rate, mean interbeat interval, and low, medium, and high frequency bands of spectral analysis were included in the study. For neuroimaging, there were two types reported: EEG and fNIRS. Figure 2 presents the flow of data process and organization.

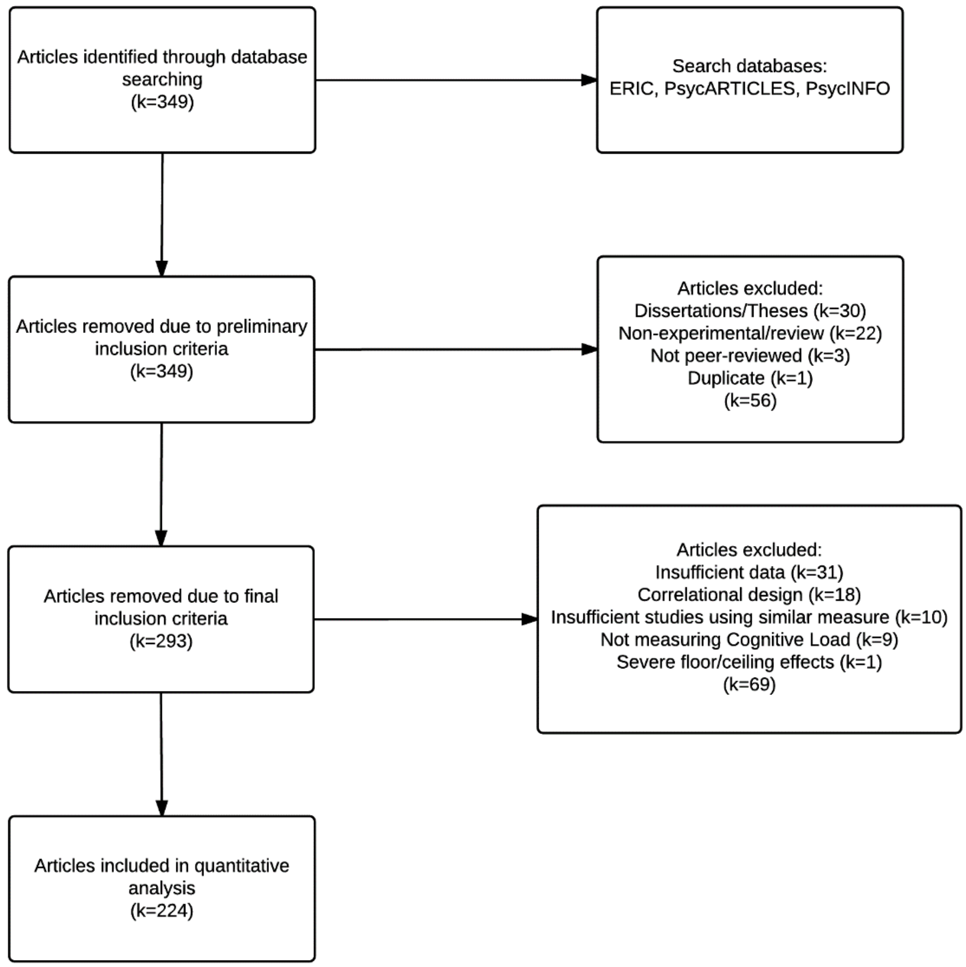

Figure 2. Flowchart of the literature assessment procedure.

Data Analysis Procedure

Random-effect Size Model

An important decision when conducting a meta-analysis review is whether to implement a fixed-effect or random-effect model. If there is very little variation between trials then I^2 will be low and a fixed effects model might be appropriate. With fixed effects all of the studies are considered to have been conducted under similar conditions with similar subjects. The random-effect model, however, allows the study outcomes to vary in a normal distribution between studies. Many investigators consider the random effects approach to be a more natural choice than fixed effects (Fleiss & Gross, 1991; Field & Gillett, 2010). As Borenstein, Hedges, Higgins, and Rothstein (2010) point out, the potential benefits of utilizing the random-effect model are (a) more likely to fit the actual sample distribution of effect sizes, (b) not limiting studies to a singular effect size, and (c) more generalizable to a wider range of situations. In the current study, the random-effect model was therefore utilized in the data analyses.

Reliability

Reliability of the coding during a meta-analysis is a significant concern. Thus, an independent volunteer performed a reliability check by coding a random sample of the codebook. The secondary rater coded 11% *(n = 26)* of the 224 publications included in the analysis. After receiving training, the secondary rater coded effect sizes, measure types (self-rating, dual task, etc.), research design (within- or between-subjects), and age. See Table 5 for a summary of the reliability check results. According to Kline (2000), coefficient alpha reliability ratings above .7 are generally acceptable.

Heterogeneity Tests

The effect sizes extracted from studies were pooled together for comparison. Variables such as age, learning content area, online/offline measure, research design, load type, and types of cognitive load measurement were also extracted and the analyses were conducted to determine their impacts on the measures of cognitive load. To ensure that the percentage of variation across studies was due to heterogeneity rather than chance, the heterogeneity analysis was performed. The Cochran's Q was calculated as the weighted sum of squared differences between individual study effects and the pooled effect across studies, with the weights being those used in the pooling method.

Table 5. Interrater reliability results: Cronbach's alpha

Category	**Alpha *(α)***
Effect Size	0.833
Research Design	0.957
Content Area	0.922
Online/Offline Measures	0.982
Peak/Overall Load	0.965

Publication Bias

Although the meta-analysis often produces an accurate synthesis of the studies, concerns exist if the studies are a biased sample of relevant studies. For example, studies that report relatively high effect sizes are more likely to be published than studies that report lower effect sizes which is known as publication bias. This issue can affect the reviews, conclusion, and consequently generalization of the findings. Therefore, a funnel plot method was employed to determine if publication biases existed in the current study.

Assumptions of the Study

A priori assumptions of the current study were that each cognitive load measure differs and that a specific load measure is mapped to a certain type of cognitive load (Cook et al., 2009). For example, self-rating may assess overall load whereas eye-track can accurately assess peak and instantaneous loads. Thus, the types of cognitive load measures may vary in their sensitivity in load assessment. A second assumption of the study is that the types of cognitive load measures may vary due to study characteristics such as age, research design, content area, and so forth. Take content area as an example, certain types of load measures like self-rating and eye-track, are more sensitive in assessing the cognitive load than other types such as dual-task.

CHAPTER IV

DATA ANALYSIS AND RESULTS

Data Analysis

Data screening was performed using the Predictive Analytics Software (PASW) Statistics 18 (2013) frequency and descriptive procedure (Table 6). As it was discussed in Chapter III, each cognitive load measure type has several levels of outcome measures. For example, the dual task method is reported by measures of response time, accuracy, time to completion, etcetera. If the outcome levels differ from one another, then they must be treated as separate variables. Otherwise, they are grouped and subsumed under the same cognitive load measure type. Analyses of variance (ANOVA) were performed with the levels of outcome measures as the independent variables and the effect size as the dependent variable to determine if there is a difference among the levels of outcome measures. For example, in the dual task measure the following levels of outcome measures are reported: dual-task response time, dual-task time to completion, dual-task interval error, and dual-task accuracy. The ANOVA results showed no significant differences among these levels of outcome measures ($F(1,3) = .295$, $p = .829$). Similar analyses were performed on other types of cognitive load measures. No significant differences were found among the levels of outcome measures for performance ($F(1,2) = 1.739$, $p = .178$), self-rating ($F(1,3) = .659$, $p = .578$), eye-track ($F(1,3) = 2.066$, $p = .113$), and physiology ($F(1,8) = .892$, $p = .527$). The above results indicate that the levels

Table 6. Frequencies for age, learning content area, online/offline measure, research design, load type and type of cognitive load measurement.

Description		Frequency	Description		Frequency
Cog load measure type	Dual task	318	**Content area**	Science	170
	Performance	234		Math	116
	Self-rating	253		Liberal arts	144
	Eye track	70		Psychology	390
	Physiology	101		Other	156
Age (missing = 10)	1-6 grades	72	**Research design**	Within subj	547
	7-12 grades	97		Between subj	429
	Adults	797	**Load type**	Peak	8
				Overall	968

of outcome measures can be treated as a single variable under their respective cognitive load measure type.

To ensure that the percentage of variation across studies was due to heterogeneity rather than chance, an analysis on heterogeneity was performed. In order to determine if publication biases existed in the current study, which could affect the reviews, the conclusion, and consequently the generalization of the findings, a funnel plot analysis was performed.

Based on the research questions, two major sets of analyses were performed. Analysis 1 aimed to find out whether there were differences among the types of cognitive load measures (Research Question 1). Analysis 2 involved analyzing the relationship between the types of cognitive load measures and their respective study characteristics: age, content area, research design, online/offline measures, load type, and the number of items used in self-rating scales (Research Questions 2, 3, 4).

Results

The R program, an open source meta-analysis computer program designed to integrate findings and analyze their variability, was employed to perform the meta-data analysis. A total of 976 studies were entered in the final analyses. The variables in the final analyses included age, the learning content area, online/offline measure, research design, load type, and types of cognitive load measures.

The Heterogeneity Test

The heterogeneity test was performed. The results showed Cochran $Q(975)=2559.049$, $p < .0001$ with total variability $I^2 = 61.32\%$. The results show that the heterogeneity test was significant indicating that the percentage of variation across studies was due to heterogeneity rather than chance. Figure 3 presents the results of the heterogeneity test.

The Funnel Plot

To determine if a publication bias existed that may affect the reviews, the conclusion, and consequently the generalization of the findings, a funnel plot analysis was performed. Figure 4 shows the results of the funnel plot with the effect size mapped on the X axis and the variance on the Y axis. The results show that although there are some outliers, the overall plot shows no evidence of significant bias in regard to the publication effect sizes in the current analysis.

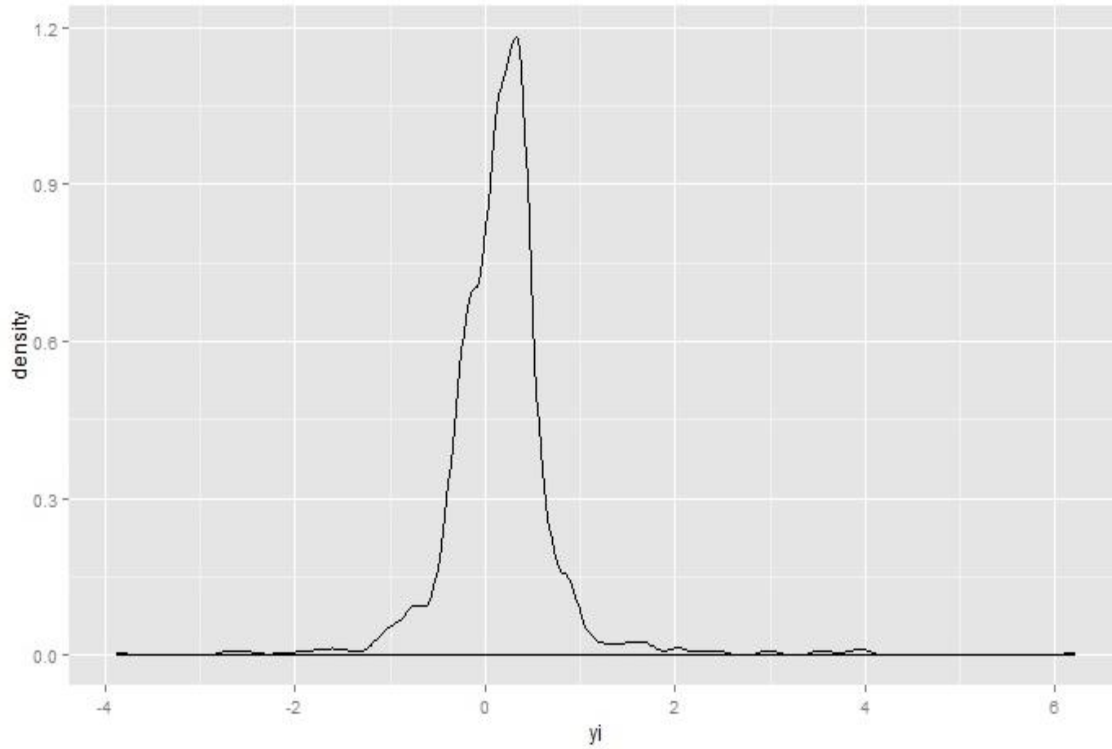

Figure 3. The heterogeneity test showing the variability of the effect sizes.

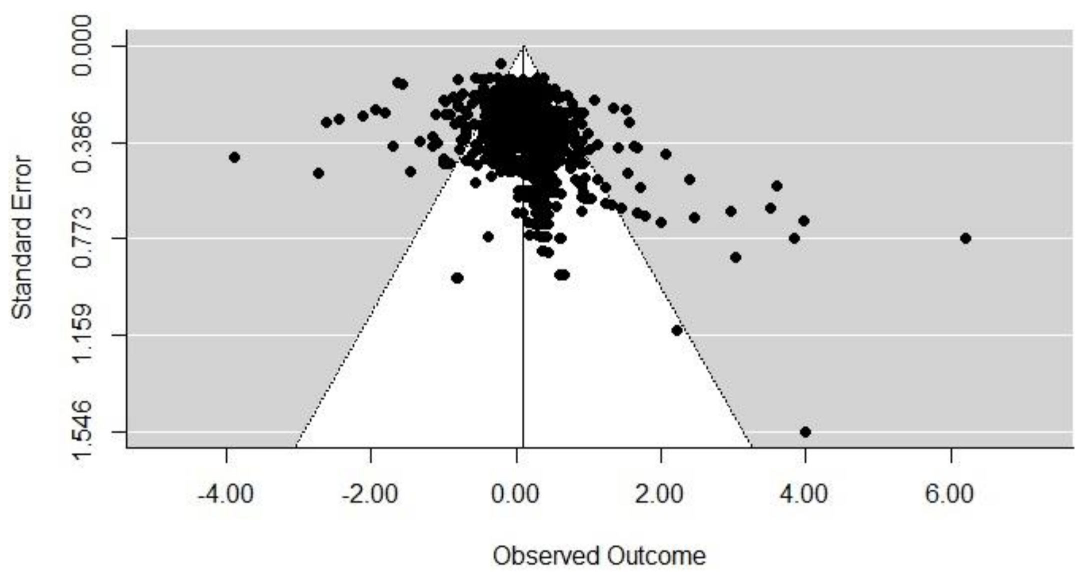

Figure 4. Cognitive load measure types – funnel plot.

Analysis 1. Differences among the Types of Cognitive Load Measures

To determine whether there were differences among the types of cognitive load measures, an ANOVA analysis was performed using IBM SPSS Statistics. Due to the imbalance in the size among the types of cognitive load measures, a formula was used to impose the weight on the effect sizes (Lane, 2015). Table 7 shows the weighted means and standard deviations of the effect sizes.

A significance was found among the types of cognitive load measures, $F(1, 4) = 53.710$, $p < .0001$. The finding suggests that overall there are differences among the types of cognitive load measures which is consistent with Cook et al. (2009) who argue that different cognitive load measures may assess different kinds of cognitive load. The mean plot indicates that eye-track and physiological methods differ from the other types of cognitive load measures, namely, dual task, performance, and self-rating (Figure 5). To further determine the sensitivity of the types of cognitive load measures in relation to study characteristics, a more fine-grained analysis was taken.

Analysis 2. Differences between Types of Cognitive Load Measures in Relation to Study Characteristics

The standard meta-analytical method was employed using R to analyze the relations between study characteristics and the types of cognitive load measures. The study characteristics were entered into multiple meta-regression models. The following presents the results of the analysis of study characteristics.

Table 7. Weighted means and standard deviations of the effect sizes for the types of cognitive load measures.

Descriptives

Weighted ES

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
dual task		318	1.3899	1.84333	.10337	1.1865	1.5933	.01	19.03	
performance		234	1.5722	1.99843	.13064	1.3148	1.8296	.02	16.16	
self-rating		253	1.4304	1.70174	.10699	1.2197	1.6411	.00	15.38	
eyetrack		70	4.6378	3.43771	.41088	3.8181	5.4575	.03	20.41	
physiology		101	3.9787	3.90102	.38817	3.2085	4.7488	.01	23.84	
Total		976	1.9450	2.52118	.08070	1.7866	2.1033	.00	23.84	
Model	Fixed Effects			2.28609	.07318	1.8014	2.0886			
	Random Effects				.61243	.2446	3.6453			1.49870

Means Plots

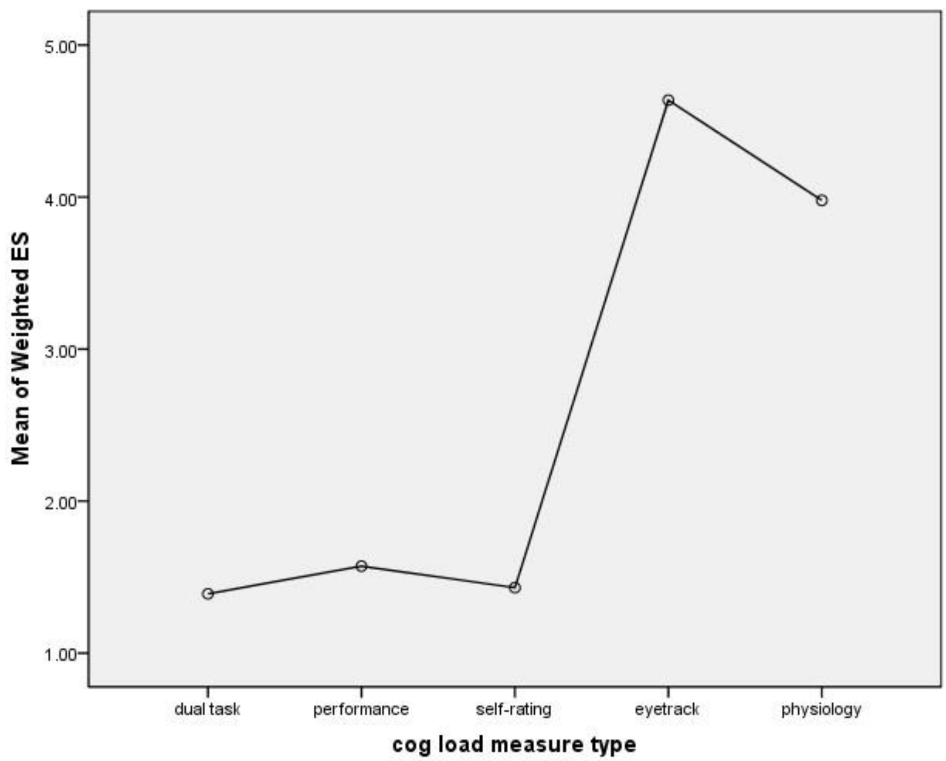

Figure 5. Mean plot for types of cognitive load measures.

Online/offline

The results of the mixed-effects model show that the online/offline variable was significant for performance measures $p < .0001$, 95% CI [-.3938, -,2632]. However, it was not significant for any other measure types.

Age

The sample age demographics include 1-6 grades, 7-12 grades, and adults. The results of mixed-effects model revealed that the sample age demographics variable was significant for eye-track ($p < .0446$, 95% CI [.0030, 2435]) and physiological method ($p < .0001$, 95% CI [.2481, 5062]), but not significant for the other three types.

Research design

The research design (within vs. between) was entered in the meta-regression analysis. The results of the mixed-effects model revealed that the research design variable was significant for performance ($p < .0001$, 95% CI [-.4716, -,3536]) but not significant for any other measure types.

Content area

The content area includes science, math, liberal arts, psychology, and so forth. The results of the mixed-effects model revealed that the content area variable was significant for self-rating ($p < .0005$, 95% CI [.0785, 2808]), eye-track ($p < .0001$, 95% CI [.2838, 4516]), and physiology ($p < .0001$, 95% CI [.1223, 3319]).

Peak/overall cognitive load

The results of the mixed-effects model revealed that the peak/overall cognitive load variable was not significant for any of the types of cognitive load measures (p <

.0830, 95% CI [-.7478, 0458]). However, it should be noted that the results approached significance suggesting greater sensitivity for peak load measures.

Self-rating items

The variable self-rating items was entered in the meta-regression model. The results revealed that the number of self-rating items variable was not significant for any of the types of cognitive load measures ($p < .5746$, 95% CI [-.1760, 0977]).

CHAPTER V

DISCUSSION

The current study has yielded important findings in regard to cognitive load measure types. Specifically, the results indicate that there are differences among the types of cognitive load measures. Moreover, the current study has identified unique relations between the types of cognitive load measures and the study characteristics such as content area, design, and so forth. Discussions on the above findings are offered based on the research questions.

Findings Based On Research Questions

Research Question 1: Which Measures Are Most Sensitive to Changes in Cognitive Load?

Research Question 1 focused on the sensitivity of the types of cognitive load measures. It was hypothesized that the sensitivity of cognitive load measures will vary significantly. The current study tried to find out if there was a difference in the types of cognitive load measures as indicated by the variance of effect sizes. The study found significant differences in the effect size, which signifies that sensitivity to changes in load varies by load measure type. Eye-track and physiological measures were found to be the most sensitive overall measures of cognitive load. In addition, the analysis of heterogeneity indicated that the difference in effect sizes was due to variance rather than chance. Thus, Hypothesis 1 was confirmed.

The observed differences in load measure sensitivity may be due to a couple of reasons. First, many studies have maintained that self-ratings are sensitive to changes in load, yet there are concerns regarding the reliability of the scales used. As mentioned previously, the cognitive load questionnaire developed by Paas (1992) has been used quite frequently, yet it has not been used in a standardized format (De Jong, 2010; van Gog & Paas, 2008; van Gog, Kirschner, Kester, & Paas, 2012). Additionally, self-ratings rely on indirect, subjective ratings from the user. It is not entirely clear how well participants can monitor their experienced load throughout the task, and factors such as learner expertise seem to influence the reliability of a learner's self-ratings (Ayres, 2006b; as cited by Beckmann, 2010).

Second, load measure sensitivity may be related to data sampling rates. For example, van Gog, Kirschner, Kester, & Paas (2012) compared the sensitivity of self-rating scales which were employed multiple times throughout a task or a single time at the end of a task. They found that it was preferable to assess load frequently throughout the task. Eye-track and physiological measures assess load at a much higher rate than self-ratings, dual-task, and performance scores. For example, eye-tracking equipment can often assess load at a rate of 50-60 Hz (Verney, Granholm, & Dionisio, 2001; van Orden, Limbert, Makeig, & Jung, 2001; Perez-Moreno, Conchillo, & Recarte, 2011; Zekveld & Kramer, 2014). On the other hand, self-ratings and performance accuracy scores are limited in the frequency they can assess cognitive load as they are obtained after the completion of an entire task or at least a portion of it (Beckmann, 2010). Increasing the sampling rate may explain the increased sensitivity of eye-tracking and physiological measures. Yet, further research would be required to determine the validity of this premise conclusively.

To determine whether similar sensitivity would appear when other factors are considered, the current study included a more fine-grained analysis that examines the correlations between cognitive load measurement sensitivity and study characteristics including age, content area, online/offline measure, load types, self-rating scale items, and research design.

Research Question 2: Is There a Correlation between Load Measurement Sensitivity and Age, Content Area, and/or Research Design?

Age

In the current study, sample age demographics, as stated previously, were comprised of age and education. Eye-track and physiological methods were found to be sensitive to changes across age demographics. The results suggest that eye-track or physiological measures become sensitive to cognitive load when taking into consideration the variable of age. The results are consistent with literature in which age is found to be significant when measuring eye movement (Di Giorgio, Turati, & Altoe, 2012; Xing & Isaacowitz, 2011). Xing and Isaacowitz (2011) used the eye-tracking technique to examine the attention of both young adults and highly educated older adults toward different types of decision-relevant information. They found that age was significantly correlated with eye movement related information processes.

Content area

Hypothesis 2b maintained that measure sensitivity would vary by the content area. Cognitive load has been studied across a vast range of content areas. Thus, it is important to understand the generalizability of load measures to diverse areas of content. Hypothesis 2b was confirmed for eye-track, physiological, and self-rating methods. These three methods were found to be sensitive to the measurement of cognitive load in a wide range of content including physical and social sciences, language, and experimental psychology tasks. The result aligns with the existing research where load sensitivity of self-ratings varied across science and language (Schrader & Bastiaens, 2012; Yeung et al., 1999).

Dual-task measures were not sensitive when considering various content areas. According to Brünken, Plass, and Leutner (2003), secondary tasks must utilize the same type of mental resources as the primary task, they must be reliable and valid, and be simple enough to avoid interfering with the primary task. Such limitations are likely to inhibit the application of dual-task measures across content. Brünken et al. further maintain that dual-task measures have been the primary method used in working memory research. The current study seemed to support that assertion as 62% *(n = 198)* of the total 318 dual-task studies utilized experimental psychology tasks. Thus, the narrow scope in which secondary tasks are applied may explain the lack of sensitivity across content areas.

Research design

Hypothesis 2c suggested that measure sensitivity would vary by research design. Only the performance method was sensitive to differences among within- and between-subjects research designs. Certain load measures are not inherently well suited for both types of research design. Physiological measures require a baseline as a reference point, and therefore are not easily implemented for between-subjects designs. If both within-and between-subjects research designs are applied within a study, then performance measures may be best suited to investigate the differences.

Offline and online measures

Hypothesis 2d maintained that measure sensitivity would vary by offline and online measures. The results partially confirmed the hypothesis showing that performance measures appear to be the only type whose sensitivity varies by offline and online measures. One possible explanation would be that eye-tracking and physiology methods are primarily used in an online measurement technique whereas self-rating always uses the offline measure technique, it is reasonable to assume that they lack the sensitivity to online/offline measures.

Performance and dual-task measures can be both online (e.g., response time) and offline (e.g., achievement) measures. However, it appears that while they are capable of both online/offline measures, they have primarily been implemented in a manner more consistent with offline measures. For instance, the reaction time outcomes were most often averaged over entire experimental conditions, which is more consistent with Xie and Salvendy's (2000) construct of average load. When reaction time outcomes are applied in this manner, it makes it impossible to assess cognitive load at any singular point.

Research Question 3: Is There a Difference in Measurement Sensitivity of Self-rating Scales That Utilize a Single Item or Multiple Items?

The self-rating questionnaire (Paas, 1992) has been widely used in cognitive load measurement. However, there is a lot of variability in terms of using the instrument.

Specifically, some use one item whereas others use all three items in cognitive load measures. Concerns have been raised in regard to the inconsistency in the use of self-rating scales in cognitive load measurement (Zheng, Miller, Snelbecker, & Cohen, 2006). It is thus hypothesized that there is a difference in measurement sensitivity of self-rating scales that utilize a single item in contrast to multiple items. Nevertheless, the results failed to find a significant difference, and therefore failed to support the hypothesis. It should be noted that overall sensitivity for self-rating measures was quite low in comparison to eye-track and physiological measures. The low overall sensitivity of self-ratings may explain the failure to observe a difference in load sensitivity between single- and multiple-item scales.

Research Question 4: Is There a Significant Difference between the Sensitivity of Peak Load Measures versus Overall Load Measures?

Finally, Research Question 4 examines the sensitivity of the type of cognitive load measures when considering peak load versus overall load measures. It was hypothesized that there is a significant difference in sensitivity between the cognitive load measure types in terms of peak load and overall load measures. Similar to Hypothesis 3, the study failed to find a significant result, which seems to suggest that there are no differences between peak and overall measures in relation to their sensitivity to cognitive load measure types. Both Xie and Salvendy (2000) and Cook, Zheng, and Blaz (2009) maintain that the cognitive load constructs vary according to specific facets such as peak and overall loads. This result did not confirm that concept.

The failure to find a difference between peak and overall load (Hypothesis 4) seems to run counter to Xie and Salvendy's (2000) framework of dynamic and static facets of cognitive load. However, the results marginally pointed toward greater sensitivity for peak load measures. Thus, the nonsignificance may be explained by several reasons. First, the sample size of peak load measure studies was quite small *(n = 8)*. With a larger sample size of peak load measures the findings may differ. Second, the measures that Cook et al. (2009) propose to be capable of investigating peak load (e.g., heart rate and neuroimaging) were solely used to measure the overall or average load of a task condition. For example, heart rate measures were only used to compare the mean heart rate of the baseline condition to that of the experimental conditions. If the measures are utilized in a manner that assesses peak load, then the findings may also differ.

Limitations of the Study

By using the meta-analysis approach, the current study is constrained by certain limitations.

Practicality of Measures

Although the results of the study demonstrate the superiority of eye-track and physiological measures, practical issues may promote the use of less sensitive measures (e.g., self-rating, dual-task). For example, self-rating measures have been widely used due to their ease of use, low cost, and lack of intrusion into the learning task (Paas, 1992; Joseph, 2014). In contrast, eye-track and physiological measures often require hardware calibration (Johnson, Liu, Thomas, & Spencer, 2007) and involve higher implementation costs (Kumar, 2006). Thus, researchers will need to identify whether practical limitations preclude the implementation of eye tracking or physiological measures.

Qualitative Data

Lipsey and Williams (2001) point out that descriptive, qualitative data obtained through means of interviews or surveys may not translate well into a meta-analysis review. Important considerations of research such as methodological quality, social context, and the complexity of the topic may be excluded due to the nature of meta-analyses which solely focus on objective, quantitative data.

Concerning the lack of qualitative data, the current study does not preclude further research into the qualitative data analysis. The purpose of the study, examining the sensitivity of cognitive load measures, lends itself well to quantitative analysis. Great care has also been taken to include only experiments that are peer-reviewed and published in order to maintain a high level of methodological quality. Although the current study includes such variables as age and learning content in the analysis, it was limited to a finite number of study characteristics. More variables should be identified in order to examine their respective effects on cognitive load measures.

Scope

The data acquisition process was carried out only through online databases. No manual search was performed due to the lack of resources such as time. In an attempt to compensate for this limitation, a large number of publications were included in the analysis for each measure type. Also, more than one online search engine was used to broaden the scope of publications coded.

The current study was also limited in its scope to published and peer-reviewed research publications. Dissertations, theses, and experiments that were not published and/or peer reviewed were excluded from the analysis. Excluding said experiments may leave out findings important to the study. It is suggested that future meta-analyses should consider including research that is not published and/or not peer reviewed (Field & Gillett, 2010; Duval & Tweedie, 2000).

In addition to the two limitations of scope listed above, the study did not include performance efficiency scores in the analysis. This measure type was excluded due to time constraints. Performance efficiency scores use both performance and self-rating measure types in a combined formula to investigate perceived difficulty in relation to achievement scores (Tuovinen & Paas, 2004; Paas & Merriënboer, 1993). It is recommended that future research consider including performance efficiency scores in order to examine their cognitive load sensitivity, especially in relation to study characteristics such as content area, sample age demographics, etc.

According to Bennett (2001), missing data rates of 10%, or greater, may influence the finding of the study. Furthermore, Schafer (1999) maintains that a missing data rate below 5% is insignificant. There were two variables in the current study where data were absent. First, the variable “number of items” pertaining to self-rating scales was not reported in 3.5% *(n = 9)* of the 253 self-rating statistics. Second, 1.0% *(n = 10)* of the total 976 studies did not report data pertaining to sample age demographics. The observed missing data rates are well below the thresholds of 5-10% mentioned above. Although the low rates of missing data may not likely affect the outcomes, it is suggested that future meta-analysis may expand the scope of search to balance the number of effect sizes in each load type.

Sample Demographics Coding

The variable of sample age demographics included two variables, namely age and education, to be subsumed into one coding category. Thus, it was not possible to attribute the effects to either factor individually. This limitation is directly related to the inherently confounded nature of age and education, and the lack of experiments controlling for either factor. Only a few experiments in the database specifically measured load in relation to age (see van Gerven, Paas, van Merriënboer, & Schmidt, 2004, 2006; Beckmann, 2010) and no experiments specifically measured load in relation to level of education. When experiments reported findings across various ages, the factor of education was either not reported or not controlled, thus confounding the ability to attribute the effects solely to age. Although both factors may influence load measurement sensitivity, it is not known to what degree age or education individually influence load sensitivity. Consequently, further research which controls for age and education, or vice versa, is needed to verify to what degree education and age individually influence load measurement sensitivity.

Future Research

Due to the limitations of the current study, there are still some issues that need to be examined.

First, the current analysis was able to identify which measures significantly varied in relation to study characteristics such as content area. However, the analysis does not have the capacity to identify the content areas for which a measure is specifically suitable. Thus, more research is warranted in order to identify the specific content areas, sample age demographics, and research designs where measures are most sensitive and suitable.

Next, the mapping (see Table 1) proposed by Cook et al. (2009) in reference to Xie and Salvendy's (2000) framework still has not been sufficiently investigated. It appears that although the framework had been proposed years ago, not much research has been conducted that attempts to measure the dynamic facets of cognitive load. The current study found only peak and overall load techniques in the database, which are only a portion of the proposed framework. More specifically, the coding of the database resulted in finding only eight studies of 976 that were able to be categorized as peak load measures. The rest of the studies fell under the category of overall load due to the research design attempting to measure accumulated load. A proper analysis with a larger sample size of peak load measures could further the preliminary analysis performed in the current study. As it stands, the results are not conclusive concerning potential differences in peak and overall load. Consequently, it is suggested that research be carried out that better utilizes the various online measures in a manner that allows them to assess the dynamic changes of cognitive load throughout a task.

In summary, the results of the current study support the theory of Cook et al. (2009), which maintains that different load measures assess discrete constructs of cognitive load. More research is needed to verify the mapping of cognitive load measures to load constructs, but the current study has shown that measures do, in fact, vary in their sensitivity. The observed effect sizes demonstrated the superiority of eye-track and physiological measures. Furthermore, the measures are also mediated by study characteristics such as age, content area, and research design.

APPENDIX A

RESEARCH LOG

04/30/2014	"cognitive load measure physiological" 1981-2014 A1:7509 results
05/01/2014	"cognitive load measure physiological" 1981-2014 A2: 7509 results
05/03/2014	"cognitive load measure physiological" 1981-2014 A3: 7509 results
05/10/2014	"cognitive load measure dual task" 1981-2014 B1: 8631 results
05/17/2014	"cognitive load measure dual task" 1981-2014 B2: 8659 results
05/24/2014	"cognitive load measure dual task" 1981-2014 B3: 8659 results
05/26/2014	"cognitive load measure" 1981-2014 C1: 123 results
05/31/2014	"cognitive load measure" 1981-2014 C2: 123 results
06/07/2014	"cognitive load measure" 1981-2014 C3: 123 results "cognitive load performance" 1981-2014 D1: 203 results
06/10/2014	"cognitive load measure eye track" 1981-2014 E1: 3010 results
06/11/2014	"cognitive load measure eye track" 1981-2014 E2: 3010 results
06/13/2014	"cognitive load measure eye track" 1981-2014 E3: 3010 results
07/14/2014	"heart rate variability cognitive load" 1981-2014 F1: 7422 results
07/15/2014	"heart rate variability cognitive load" 1981-2014 F2: 7422 results "pupil cognitive load" 1981-2014 G1: 10 results "physiological cognitive load" 1981-2014 H1: 6 results
07/16/2014	"eye blink cognitive load" 1981-2014 J1: 1190 results
03/15/2015	"Subjective Mental Workload" 1981-2015 K1: 61 results, filter: peer-reviewed "cognitive load pupil" 1981-2015 L1: 11 results, filter: peer-reviewed "cognitive task difficulty" 1981-2015 M1: 220 results, filter: peer-reviewed "overall cognitive load" 1981-2015 N1: 21 results, filter: peer-reviewed "cognitive load performance" 1981-2015 D2: 179 results, filter: peer-reviewed "cognitive load measurement" 1981-2015 O1: 28 results, filter: peer-reviewed "cognitive load measure split" 1981-2015 P1: 1994 results, filter: peer-reviewed "cognitive load measure integrated" 1981-2015 Q1: 6189 results, filter: peer-reviewed "cognitive load problems" 1981-2015 R1: 77 results, filter: peer-reviewed "information processing load" 1981-2015 S1: 134 results, filter: peer-reviewed "cognitive load theory" 1981-2015 T1: 465 results, filter: peer-reviewed

	“cognitive load graphical” 1981-2015 U1: 4 results, filter: peer-reviewed “cognitive load evaluation” 1981-2015 V1: 13 results, filter: peer-reviewed “cognitive load comprehension” 1981-2015 W1: 23 results, filter: peer-reviewed
3/16/2015	“cognitive” and “overload” 1981-2015: X1: 521 results, filter: peer-reviewed, full text “cognitive load” and “speech” 1981-2015: Y1: 136 results, filter: peer-reviewed “cognitive load multimedia” 1981-2015: Z1: 71 results, filter: peer-reviewed “Subjective Workload” 1981-2015 K2: 304 results, filter: peer-reviewed

APPENDIX B

CODEBOOK LEGEND

<table>
<tr>
<td>Code

1=Dual Task
2=Performance
3=Self-Rating
4=Eye Track
5=Physiology</td>
<td rowspan="3">Subcode

1=Dual Task: RT
2= Dual Task: Completion Time
3=Dual Task: Interval Error
4=Dual Task Accuracy Score
5=Perf. Accuracy Score
6=Perf. Completion Time
7=Performance: RT
8=Self-Rating: Mental Effort
9=Self-Rating: Task Difficulty
10=Self-Rating: Workload
11=Self-Rating: NASA-TLX
12=Fixation Duration
13=Fixation Frequency
14=Blink*
15=Mean Pupil Size
16=Peak Pupil Size
17=Mean Heart Rate
18=HRV: Interbeat Interval
19=HRV: Low Frequency Band
20=HRV: Mid Frequency Band
21=HRV: High Frequency Band
22=Systolic Blood Pressure
23=Diastolic Blood Pressure
24=Neuroimaging: EEG
25=Neuroimaging: fNIRS</td>
<td>Demographic

1=Grades K-6
2=Grades 7-12
3=Adults (Age 18+)</td>
</tr>
<tr>
<td>ES (Effect Size) Direction

1=Increase Cognitive Load
2=Decrease Cognitive Load</td>
<td>Content

1=Science
2=Math
3=Liberal Arts
4=Psychology Task
5=Other</td>
</tr>
<tr>
<td>Design

1=Within Subjects
2=Between Subjects</td>
<td>SRating (Self-Rating)

1=1 Item Scale
2=Multiple Item Scale</td>
</tr>
</table>

*Excluded from analysis due to scarcity

APPENDIX C

GENERAL CODEBOOK

StudyID	Code	Subcode	(n=)	ESDirection	ES	Design	Demographic	Content	On/Offline	Peak/Overall
1	1	1	24	1	3.9662	1	3	4	2	2
2	1	1	24	1	3.5003	1	3	4	2	2
3	1	1	24	1	0.9053	1	3	4	2	2
4	1	1	24	1	0.6399	1	3	4	2	2
5	1	1	96	1	0.57	2	3	4	2	2
6	1	1	96	1	0.44	2	3	4	2	2
7	1	1	112	1	0.05	2	3	4	2	2
8	1	1	10	1	0.4289	1	3	1	2	2
9	1	1	10	1	0.4123	1	3	3	2	2
10	1	1	73	-1	0.3379	1	3	4	2	2
11	1	1	56	1	0.57	1	3	3	2	2
12	1	1	54	1	0.53	2	3	1	2	2
13	1	1	54	1	0.25	1	3	1	2	2
14	1	1	96	1	0.48	2	3	1	2	2
15	1	1	96	1	0.0659	1	3	1	2	2
16	1	1	24	-1	0.1267	2	1	1	2	2
17	1	1	24	1	0.1072	1	1	1	2	2
18	1	1	80	1	0.2089	2	3	2	2	2
19	1	1	80	-1	0.0726	2	3	2	2	2
20	1	1	10	1	0.4202	1	3	1	2	2
21	1	1	10	1	0.3097	1	3	3	2	2
22	1	1	36	1	0.2596	2	3	1	2	2
23	1	1	33	-1	0.065	2	3	1	2	2
24	1	1	27	1	0.273	1		3	2	2
25	1	1	27	1	0.2272	1		3	2	2
26	1	1	35	1	0.747	1	3	4	2	2
27	1	1	35	1	0.736	1	3	4	2	2
28	1	1	35	1	0.649	1	3	4	2	2
29	1	1	35	1	0.589	1	3	4	2	2
30	1	1	35	1	0.2364	1	3	5	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
31	1	1	96	-1	0.17	1	3	1	2	2
32	1	1	96	-1	0.09	1	3	1	2	2
33	1	1	47	1	0.44	1	3	3	2	2
34	1	1	47	1	0.03	2	3	3	2	2
35	1	1	40	1	0.59	1	3	3	2	2
36	1	1	40	1	0.06	2	3	3	2	2
37	1	1	30	1	0.3191	1	3	5	2	2
38	1	1	33	1	3.5863	1	3	4	2	2
39	1	1	33	1	2.0737	1	3	4	2	2
40	1	1	33	1	0.13	2	3	4	2	2
41	1	1	46	1	0.67	1	3	5	2	2
42	1	1	28	1	0.641	1	3	4	2	2
43	1	1	28	1	0.16	1	3	4	2	2
44	1	1	17	1	0.412	1	3	4	2	2
45	1	1	17	1	0.059	1	3	4	2	2
46	1	1	40	1	0.24	1	3	4	2	2
47	1	1	18	1	0.754	1	3	3	2	2
48	1	1	18	1	0.283	2	3	3	2	2
49	1	1	18	1	0.102	1	3	3	2	2
50	1	1	20	1	0.88	1	3	4	2	2
51	1	1	20	1	0.62	1	3	4	2	2
52	1	1	20	1	0.56	1	3	4	2	2
53	1	1	24	1	0.88	1	3	4	2	2
54	1	1	24	1	0.64	1	3	4	2	2
55	1	1	24	1	0.18	1	3	4	2	2
56	1	1	25	1	0.87	1	3	4	2	2
57	1	1	25	1	0.49	1	3	4	2	2
58	1	1	25	1	0.42	1	3	4	2	2
59	1	1	10	1	0.901	1	3	4	2	2
60	1	1	14	1	0.9	1	3	4	2	2
61	1	1	13	1	0.928	1	3	4	2	2
62	1	1	10	1	0.2459	1	3	4	2	2
63	1	1	10	1	0.565	1	3	4	2	2
64	1	1	20	-1	0.31	2	3	4	2	2
65	1	1	98	1	0.21	2	3	5	2	2
66	1	1	79	1	0.3	2	3	5	2	2
67	1	1	21	1	0.5	1	3	4	2	2
68	1	1	21	1	0.24	1	3	4	2	2
69	1	1	24	1	0.44	1	3	4	2	2
70	1	1	24	1	0.28	1	3	4	2	2
71	1	1	25	1	0.6	1	3	4	2	2
72	1	1	25	1	0.35	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
73	1	1	21	1	0.37	1	3	4	2	2
74	1	1	21	1	0.37	1	3	4	2	2
75	1	1	24	1	0.68	1	3	4	2	2
76	1	1	24	1	0.39	1	3	4	2	2
77	1	1	115	1	0.17	2	3	4	2	2
78	1	1	169	1	0.12	2	3	3	2	2
79	1	1	169	1	0.02	2	3	3	2	2
80	1	1	16	1	0.3248	1	3	4	2	2
81	1	1	16	1	0.307	1	3	4	2	2
82	1	1	26	1	0.4187	1	3	4	2	2
83	1	1	26	1	0.41	1	3	4	2	2
84	1	1	26	1	0.3969	1	3	4	2	2
85	1	1	26	1	0.3901	1	3	4	2	2
86	1	1	26	1	0.3874	1	3	4	2	2
87	1	1	29	1	0.4186	1	3	4	2	2
88	1	1	29	1	0.3929	1	3	4	2	2
89	1	1	29	1	0.3877	1	3	4	2	2
90	1	1	29	1	0.373	1	3	4	2	2
91	1	1	29	1	0.3639	1	3	4	2	2
92	1	1	18	1	0.4357	1	3	4	2	2
93	1	1	18	1	0.4294	1	3	4	2	2
94	1	1	18	1	0.371	1	3	4	2	2
95	1	1	18	1	0.3387	1	3	4	2	2
96	1	1	18	1	0.2516	1	3	4	2	2
97	1	1	41	1	0.7656	2	3	3	2	2
98	1	1	41	1	0.1121	2	3	3	2	2
99	1	1	40	1	0.516	1	3	2	2	2
100	1	1	40	1	0.0924	2	3	2	2	2
101	1	1	40	1	0.0764	2	3	2	2	2
102	1	1	40	1	0.0694	1	3	2	2	2
103	1	1	71	1	0.4287	1	3	4	2	2
104	1	1	71	1	0.3659	1	3	4	2	2
105	1	1	71	1	0.1077	2	3	4	2	2
106	1	1	16	1	1.1174	1	3	4	2	2
107	1	1	16	1	0.9457	1	3	4	2	2
108	1	1	24	1	0.49	1	3	3	2	2
109	1	1	28	1	0.35	1	3	3	2	2
110	1	1	47	1	0.3408	1	3	4	2	2
111	1	1	40	1	0.2606	2	3	5	2	2
112	1	1	40	1	0.1742	1	3	5	2	2
113	1	1	40	1	0.0691	1	3	5	2	2
114	1	1	28	1	0.42	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
115	1	1	28	1	0.3	1	3	4	2	2
116	1	1	28	-1	0.28	1	3	4	2	2
117	1	1	28	1	0.1446	1	3	4	2	2
118	1	1	27	-1	0.56	1	3	4	2	2
119	1	1	27	1	0.43	1	3	4	2	2
120	1	1	27	1	0.4	1	3	4	2	2
121	1	1	27	1	0.32	1	3	4	2	2
122	1	1	55	1	0.19	1	3	4	2	2
123	1	1	55	1	0.0115	2	3	4	2	2
124	1	1	40	-1	0.69	1	3	4	2	2
125	1	1	40	1	0.46	1	3	4	2	2
126	1	1	40	1	0.21	1	3	4	2	2
127	1	1	40	1	0.076	1	3	4	2	2
128	1	1	40	1	0.0562	1	3	4	2	2
129	1	1	71	-1	0.14	1	3	4	2	2
130	1	1	71	1	0.1143	1	3	4	2	2
131	1	1	71	1	0.0963	1	3	4	2	2
132	1	1	71	1	0.0799	1	3	4	2	2
133	1	1	71	1	0.072	2	3	4	2	2
134	1	1	71	1	0.0706	1	3	4	2	2
135	1	1	71	1	0.0312	1	3	4	2	2
136	1	1	20	1	0.73	1	3	4	2	2
137	1	1	20	1	0.53	1	3	4	2	2
138	1	1	19	1	3.8289	1	3	4	2	2
139	1	1	19	1	2.9631	1	3	4	2	2
140	1	1	12	1	1.9968	1	3	4	2	2
141	1	1	12	1	1.3235	1	3	4	2	2
142	1	1	48	-1	0.3602	1	3	4	2	2
143	1	1	24	1	0.2636	1	3	4	2	2
144	1	1	24	1	0.2517	1	3	4	2	2
145	1	1	24	1	0.2389	1	3	4	2	2
146	1	1	24	-1	0.3964	1	3	4	2	2
147	1	1	24	1	0.2203	1	3	4	2	2
148	1	1	24	1	0.1462	1	3	4	2	2
149	1	1	24	1	0.0856	1	3	4	2	2
150	1	1	9	1	0.2948	1	3	4	2	2
151	1	1	24	1	0.3376	1	3	5	2	2
152	1	1	16	1	0.401	1	3	5	2	2
153	1	1	7	1	0.3911	1	3	4	2	2
154	1	1	60	1	0.89	1	3	4	2	2
155	1	1	60	1	0.72	1	3	4	2	2
156	1	1	60	1	0.51	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
157	1	1	96	1	0.11	2	3	5	2	2
158	1	1	12	1	0.4049	1	3	4	2	2
159	1	1	13	1	0.3973	1	3	4	2	2
160	1	1	12	1	0.0425	1	3	4	2	2
161	1	1	13	1	0.2927	1	3	4	2	2
162	1	1	8	1	0.3922	1	3	4	2	2
163	1	1	17	1	1.7183	1	3	5	1	2
164	1	2	24	1	0.85	1	3	4	2	2
165	1	2	39	1	6.2	2	1	1	2	2
166	1	2	18	1	0.3441	1	1	5	2	2
167	1	2	18	1	0.3325	1	1	5	2	2
168	1	2	16	1	0.4538	1	3	4	2	2
169	1	2	16	1	0.39	1	3	4	2	2
170	1	2	24	1	0.63	1	3	3	2	2
171	1	2	28	1	0.42	1	3	3	2	2
172	1	2	12	1	0.513	1	3	5	2	2
173	1	2	12	1	0.1109	1	3	5	2	2
174	1	2	16	-1	0.1036	1	3	5	2	2
175	1	2	16	1	0.0544	1	3	5	2	2
176	1	3	30	1	0.3738	1	3	5	2	2
177	1	3	30	1	0.3014	1	3	5	2	2
178	1	3	30	1	0.8693	2	3	3	2	2
179	1	3	30	1	0.3896	2	3	3	2	2
180	1	4	24	1	0.19	1	3	4	2	2
181	1	4	24	1	0.13	1	3	4	2	2
182	1	4	96	1	0.29	2	3	4	2	2
183	1	4	96	1	0.18	2	3	4	2	2
184	1	4	112	1	0.28	2	3	4	2	2
185	1	4	75	-1	0.3214	1	3	4	2	2
186	1	4	75	-1	0.2898	1	3	4	2	2
187	1	4	75	-1	0.2404	2	3	4	2	2
188	1	4	75	-1	0.207	2	3	4	2	2
189	1	4	75	-1	0.1862	2	3	4	2	2
190	1	4	75	-1	0.1818	2	3	4	2	2
191	1	4	75	-1	0.1807	2	3	4	2	2
192	1	4	75	-1	0.1707	2	3	4	2	2
193	1	4	73	-1	0.3444	1	3	4	2	2
194	1	4	73	-1	0.3325	1	3	4	2	2
195	1	4	73	-1	0.2309	2	3	4	2	2
196	1	4	73	-1	0.2189	2	3	4	2	2
197	1	4	30	-1	0.4288	1	3	5	2	2
198	1	4	30	-1	0.3223	2	3	5	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
199	1	4	42	1	0.3572	1	3	4	2	2
200	1	4	24	-1	0.3354	2	1	1	2	2
201	1	4	24	1	0.0466	1	1	1	2	2
202	1	4	19	1	0.1918	1	2	2	2	2
203	1	4	19	1	0.0639	1	2	2	2	2
204	1	4	35	1	0.627	1	3	4	2	2
205	1	4	35	1	0.6	1	3	4	2	2
206	1	4	35	1	0.141	1	3	4	2	2
207	1	4	35	1	0.14	1	3	4	2	2
208	1	4	35	1	0.125	1	3	4	2	2
209	1	4	35	1	0.114	1	3	4	2	2
210	1	4	35	1	0.1054	1	3	4	2	2
211	1	4	35	1	0.3179	1	3	5	2	2
212	1	4	47	1	0.52	1	3	3	2	2
213	1	4	40	1	0.39	1	3	3	2	2
214	1	4	40	1	0.1	2	3	3	2	2
215	1	4	33	1	1.6821	1	3	4	2	2
216	1	4	33	1	1.6316	1	3	4	2	2
217	1	4	33	1	0.15	2	3	4	2	2
218	1	4	46	1	0.91	1	3	5	2	2
219	1	4	46	1	0.81	1	3	5	2	2
220	1	4	46	1	0.39	1	3	5	2	2
221	1	4	28	1	0.33	1	3	4	2	2
222	1	4	28	1	0.099	1	3	4	2	2
223	1	4	17	1	0.007	1	3	4	2	2
224	1	4	17	1	0.002	1	3	4	2	2
225	1	4	35	1	0.23	2	3	4	2	2
226	1	4	18	1	0.432	1	3	3	2	2
227	1	4	18	1	0.139	2	3	3	2	2
228	1	4	20	1	0.31	1	3	4	2	2
229	1	4	20	1	0.23	1	3	4	2	2
230	1	4	20	-1	0.22	1	3	4	2	2
231	1	4	20	1	0.19	1	3	4	2	2
232	1	4	24	-1	0.19	1	3	4	2	2
233	1	4	25	1	0.13	1	3	4	2	2
234	1	4	12	1	0.4433	1	3	5	2	2
235	1	4	12	1	0.427	1	3	5	2	2
236	1	4	64	1	0.82	1	3	4	2	2
237	1	4	64	1	0.31	2	3	4	2	2
238	1	4	10	1	0.255	1	3	4	2	2
239	1	4	14	1	0.523	1	3	4	2	2
240	1	4	13	1	0.326	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
241	1	4	98	1	0.16	2	3	5	2	2
242	1	4	79	1	0.35	2	3	5	2	2
243	1	4	21	-1	0.19	1	3	4	2	2
244	1	4	24	-1	0.37	1	3	4	2	2
245	1	4	21	1	0.42	1	3	4	2	2
246	1	4	21	-1	0.23	1	3	4	2	2
247	1	4	115	1	0.28	2	3	4	2	2
248	1	4	115	1	0.03	2	3	4	2	2
249	1	4	91	1	0.3453	1	3	4	2	2
250	1	4	91	1	0.2144	2	3	4	2	2
251	1	4	169	1	0.23	2	3	3	2	2
252	1	4	169	1	0.07	2	3	3	2	2
253	1	4	169	1	0.02	2	3	3	2	2
254	1	4	48	1	0.2473	2	3	5	2	2
255	1	4	48	1	0.0761	2	3	5	2	2
256	1	4	16	1	0.3883	1	3	4	2	2
257	1	4	16	1	0.2451	1	3	4	2	2
258	1	4	61	1	0.925	1	3	4	2	2
259	1	4	61	1	0.896	1	3	4	2	2
260	1	4	41	1	0.7144	2	3	3	2	2
261	1	4	41	1	0.2947	2	3	3	2	2
262	1	4	40	1	0.545	1	3	2	2	2
263	1	4	40	1	0.387	1	3	2	2	2
264	1	4	40	1	0.161	2	3	2	2	2
265	1	4	40	1	0.0979	2	3	2	2	2
266	1	4	18	1	0.2643	1	1	5	2	2
267	1	4	71	1	0.2895	1	3	4	2	2
268	1	4	71	1	0.1411	2	3	4	2	2
269	1	4	16	1	1.1174	1	3	4	2	2
270	1	4	24	1	0.84	1	3	3	2	2
271	1	4	24	1	0.16	1	3	3	2	2
272	1	4	28	1	0.82	1	3	3	2	2
273	1	4	28	1	0.43	1	3	3	2	2
274	1	4	28	1	0.41	1	3	3	2	2
275	1	4	28	1	0.22	1	3	3	2	2
276	1	4	28	1	0.16	1	3	3	2	2
277	1	4	28	1	0.07	1	3	3	2	2
278	1	4	32	-1	0.415	1	3	4	2	2
279	1	4	20	1	0.93	1	3	4	2	2
280	1	4	20	-1	0.696	1	3	4	2	2
281	1	4	20	1	0.57	1	3	4	2	2
282	1	4	20	-1	0.178	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
283	1	4	56	1	0.5243	1	3	5	2	2
284	1	4	56	1	0.4743	1	3	5	2	2
285	1	4	56	-1	0.3476	2	3	5	2	2
286	1	4	15	1	0.4804	1	3	4	2	2
287	1	4	18	1	0.45	1	3	5	2	2
288	1	4	18	-1	0.32	1	3	5	2	2
289	1	4	18	1	0.31	2	3	5	2	2
290	1	4	18	1	0.26	1	3	5	2	2
291	1	4	140	1	0.344	2	3	4	2	2
292	1	4	120	1	0.1766	2	3	4	2	2
293	1	4	140	1	0.0878	2	3	4	2	2
294	1	4	30	1	0.6066	1	3	4	2	2
295	1	4	20	-1	0.0559	1	3	4	2	2
296	1	4	24	1	0.3853	1	3	5	2	2
297	1	4	7	1	0.3528	1	3	4	2	2
298	1	4	60	1	0.9	1	3	4	2	2
299	1	4	60	1	0.73	1	3	4	2	2
300	1	4	60	1	0.25	1	3	4	2	2
301	1	4	60	1	0.09	2	3	4	2	2
302	1	4	12	1	1.6792	1	3	5	2	2
303	1	4	12	1	1.0293	1	3	5	2	2
304	1	4	58	1	0.6842	2	2	5	2	2
305	1	4	58	-1	0.0527	2	2	5	2	2
306	1	4	192	1	0.19	2	3	5	2	2
307	1	4	12	1	0.4247	1	3	5	2	2
308	1	4	13	1	0.4132	1	3	4	2	2
309	1	4	13	1	0.3314	1	3	4	2	2
310	1	4	12	1	0.3301	1	3	4	2	2
311	1	4	16	1	0.0679	1	3	5	2	2
312	1	4	16	-1	0.0633	1	3	5	2	2
313	1	4	96	-1	1.0027	2	2	1	2	2
314	1	4	14	1	0.2932	1	3	5	2	2
315	1	4	15	1	0.3442	1	3	5	2	2
316	1	4	15	1	0.26	1	3	5	2	2
317	1	4	30	1	0.149	1	3	4	2	2
318	1	4	30	1	0.0433	1	3	4	2	2
319	2	5	15	-1	0.3401	1	3	4	2	2
320	2	5	15	-1	0.3299	1	3	4	2	2
321	2	5	30	1	0.5268	2	3	5	2	2
322	2	5	30	-1	0.3067	2	3	5	2	2
323	2	5	86	-1	0.1482	2	3	1	2	2
324	2	5	86	-1	0.1197	2	3	1	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
325	2	5	97	-1	0.2768	2	3	1	2	2
326	2	5	97	-1	0.0724	2	3	1	2	2
327	2	5	30	-1	1.0874	2	3	1	2	2
328	2	5	30	1	0.1962	2	3	1	2	2
329	2	5	29	-1	1.1473	2	3	1	2	2
330	2	5	29	1	0.3046	2	3	1	2	2
331	2	5	90	-1	0.47	2	3	1	2	2
332	2	5	90	-1	0.04	2	3	1	2	2
333	2	5	62	-1	0.7	2	3	1	2	2
334	2	5	62	1	0.15	2	3	1	2	2
335	2	5	98	-1	0.5	2	3	1	2	2
336	2	5	98	-1	0.23	2	3	1	2	2
337	2	5	98	1	0.12	2	3	1	2	2
338	2	5	98	1	0.05	2	3	1	2	2
339	2	5	53	-1	0.4341	2	3	1	2	2
340	2	5	53	-1	0.2256	2	3	1	2	2
341	2	5	31	-1	0.71	2	3	1	2	2
342	2	5	31	-1	0.3412	2	3	1	2	2
343	2	5	30	-1	1.12	2	1	3	2	2
344	2	5	30	1	0.5329	2	1	3	2	2
345	2	5	40	-1	0.192	2	3	2	2	2
346	2	5	40	-1	0.133	2	3	2	2	2
347	2	5	40	-1	0.1235	2	3	2	2	2
348	2	5	40	-1	0.0359	2	3	2	2	2
349	2	5	26	-1	0.317	2	3	2	2	2
350	2	5	26	-1	0.186	2	3	2	2	2
351	2	5	26	-1	0.157	2	3	2	2	2
352	2	5	26	-1	0.1342	2	3	2	2	2
353	2	5	57	-1	0.411	2	3	1	2	2
354	2	5	57	-1	0.242	2	3	1	2	2
355	2	5	98	-1	0.179	2	3	1	2	2
356	2	5	57	-1	0.153	2	3	1	2	2
357	2	5	98	-1	0.146	2	3	1	2	2
358	2	5	98	-1	0.14	2	3	1	2	2
359	2	5	98	1	0.104	2	3	1	2	2
360	2	5	98	1	0.092	2	3	1	2	2
361	2	5	98	1	0.087	2	3	1	2	2
362	2	5	98	-1	0.078	2	3	1	2	2
363	2	5	98	1	0.047	2	3	1	2	2
364	2	5	98	-1	0.038	2	3	1	2	2
365	2	5	24	-1	0.5169	1	1	3	2	2
366	2	5	24	-1	0.2333	1	1	3	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
367	2	5	24	-1	0.325	1	1	3	2	2
368	2	5	24	1	0.2757	1	1	3	2	2
369	2	5	14	-1	0.5677	1	3	3	2	2
370	2	5	14	1	0.5652	1	3	3	2	2
371	2	5	56	1	1.5575	2	2	3	2	2
372	2	5	56	-1	0.1406	2	2	3	2	2
373	2	5	57	1	0.5538	2	2	3	2	2
374	2	5	57	-1	0.395	2	2	3	2	2
375	2	5	10	1	0.3261	1	2	2	2	2
376	2	5	48	1	0.0157	2	2	2	2	2
377	2	5	231	-1	0.47	1	3	4	2	2
378	2	5	231	1	0.37	1	3	4	2	2
379	2	5	231	1	0.35	2	3	4	2	2
380	2	5	28	-1	0.3743	2	3	1	2	2
381	2	5	28	-1	0.2419	2	3	1	2	2
382	2	5	28	1	0.1249	2	3	1	2	2
383	2	5	60	1	0.45	1		3	2	2
384	2	5	24	1	0.1555	1	1	3	2	2
385	2	5	30	1	0.4103	1	1	4	2	2
386	2	5	30	1	0.1796	1	1	4	2	2
387	2	5	25	1	0.187	1	1	4	2	2
388	2	5	26	1	0.376	1	1	4	2	2
389	2	5	26	1	0.1594	1	1	4	2	2
390	2	5	28	1	0.1982	1	1	4	2	2
391	2	5	28	1	0.172	1	1	4	2	2
392	2	5	24	1	0.1752	1	3	3	2	2
393	2	5	30	1	0.68	1	3	4	2	2
394	2	5	30	1	0.091	2	3	4	2	2
395	2	5	36	1	0.692	1	3	4	2	2
396	2	5	36	1	0.051	2	3	4	2	2
397	2	5	40	-1	0.12	2	3	1	2	2
398	2	5	134	-1	0.2558	2	1	3	2	2
399	2	5	134	1	0.1542	2	1	3	2	2
400	2	5	126	-1	0.2959	2	2	3	2	2
401	2	5	126	1	0.0381	2	2	3	2	2
402	2	5	25	-1	0.3503	2	3	3	2	2
403	2	5	25	-1	0.1948	2	3	3	2	2
404	2	5	32	1	0.28	1	3	3	2	2
405	2	5	26	-1	0.22	2	1	4	2	2
406	2	5	24	-1	0.2	2	1	4	2	2
407	2	5	24	-1	0.04	2	1	4	2	2
408	2	5	24	1	0.005	2	1	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
409	2	5	66	-1	0.386	2	1	4	2	2
410	2	5	66	-1	0.004	2	1	4	2	2
411	2	5	42	-1	0.164	2	1	1	2	2
412	2	5	42	1	0.158	2	1	1	2	2
413	2	5	30	1	0.4097	1	3	5	2	2
414	2	5	30	1	0.3768	1	3	5	2	2
415	2	5	42	-1	0.7139	2	2	2	2	2
416	2	5	42	-1	0.5901	2	2	2	2	2
417	2	5	42	1	0.1147	2	2	2	2	2
418	2	5	26	-1	0.1746	2	2	2	2	2
419	2	5	25	1	0.3243	1	3	4	2	2
420	2	5	12	1	0.4359	1	3	5	2	2
421	2	5	12	1	0.0698	1	3	5	2	2
422	2	5	24	1	0.1468	1	3	2	2	2
423	2	5	24	1	0.1134	1	3	4	2	2
424	2	5	24	1	0.2018	1	3	4	2	2
425	2	5	21	-1	0.34	1	3	4	2	2
426	2	5	36	1	0.2662	1	3	4	2	2
427	2	5	21	-1	0.24	1	3	4	2	2
428	2	5	36	1	0.1962	1	3	4	2	2
429	2	5	36	1	0.1835	2	3	4	2	2
430	2	5	257	-1	1.62	2	2	1	2	2
431	2	5	257	-1	0.55	2	2	1	2	2
432	2	5	257	1	0.39	2	2	1	2	2
433	2	5	257	-1	0.37	2	2	1	2	2
434	2	5	257	1	0.29	2	2	1	2	2
435	2	5	257	-1	0.25	2	2	1	2	2
436	2	5	106	-1	0.1646	2	3	3	2	2
437	2	5	106	-1	0.1492	2	3	3	2	2
438	2	5	12	1	1.99	1	3	4	2	2
439	2	5	12	1	0.37	1	3	4	2	2
440	2	5	153	-1	0.18	2	2	1	2	2
441	2	5	128	-1	0.01	2	2	1	2	2
442	2	5	79	-1	0.1	2	2	3	2	2
443	2	5	79	-1	0.09	2	2	3	2	2
444	2	5	79	-1	0.08	2	2	3	2	2
445	2	5	77	-1	0.08	2	2	3	2	2
446	2	5	77	1	0.0775	2	2	3	2	2
447	2	5	58	-1	3.8749	2	3	1	2	2
448	2	5	57	-1	0.239	2	3	1	2	2
449	2	5	34	-1	1.7059	2	3	3	2	2
450	2	5	34	-1	1.3343	2	3	3	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
451	2	5	20	-1	0.269	2	3	3	2	2
452	2	5	20	-1	0.126	2	3	3	2	2
453	2	5	29	-1	0.3136	1	2	1	2	2
454	2	5	52	-1	0.1827	2	2	1	2	2
455	2	5	100	-1	0.2028	2	2	1	2	2
456	2	5	156	1	0.037	2	2	2	2	2
457	2	5	156	1	0.034	2	2	2	2	2
458	2	5	156	1	0.024	2	2	2	2	2
459	2	5	117	-1	0.1762	2	3	1	2	2
460	2	5	32	1	0.3522	1	3	4	2	2
461	2	5	31	1	0.0744	2	3	4	2	2
462	2	5	12	1	0.4128	1	3	4	2	2
463	2	5	12	1	0.2781	1	3	4	2	2
464	2	5	24	1	0.3485	1	3	4	2	2
465	2	5	16	1	0.137	1	3	4	2	2
466	2	6	30	-1	0.3625	2	3	5	2	2
467	2	6	30	-1	0.2661	2	2	2	2	2
468	2	6	30	-1	0.2482	2	2	2	2	2
469	2	6	30	-1	0.192	2	2	2	2	2
470	2	6	30	-1	0.2268	2	2	2	2	2
471	2	6	30	-1	0.1801	2	2	2	2	2
472	2	6	30	-1	0.1641	2	2	2	2	2
473	2	6	40	-1	0.2486	2	2	2	2	2
474	2	6	40	-1	0.2365	2	2	2	2	2
475	2	6	40	-1	0.1496	2	2	2	2	2
476	2	6	40	1	0.0827	2	2	2	2	2
477	2	6	40	-1	0.2012	2	2	2	2	2
478	2	6	40	-1	0.1762	2	2	2	2	2
479	2	6	40	-1	0.1303	2	2	2	2	2
480	2	6	40	-1	0.2768	2	1	2	2	2
481	2	6	40	-1	0.2635	2	1	2	2	2
482	2	6	40	-1	0.2201	2	1	2	2	2
483	2	6	40	-1	0.1848	2	1	2	2	2
484	2	6	40	-1	0.1792	2	1	2	2	2
485	2	6	40	-1	0.1647	2	1	2	2	2
486	2	6	20	-1	0.9994	2	1	2	2	2
487	2	6	20	-1	0.4243	2	1	2	2	2
488	2	6	20	-1	0.099	2	1	2	2	2
489	2	6	91	-1	1.9318	2	3	5	2	2
490	2	6	20	1	1.5462	2	3	1	2	2
491	2	6	30	-1	2.7301	2	2	1	2	2
492	2	6	24	1	0.1592	1	1	3	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
493	2	6	40	1	0.1	2		1	2	2
494	2	6	32	-1	0.34	2	1	4	2	2
495	2	6	32	-1	0.2	2	1	4	2	2
496	2	6	20	1	0.3716	1	3	1	2	2
497	2	6	45	-1	0.8325	1	2	2	2	2
498	2	6	20	-1	0.6388	1	2	2	2	2
499	2	6	45	-1	0.1871	2	1	2	2	2
500	2	6	30	-1	0.7181	2	1	4	2	2
501	2	6	30	-1	0.4649	2	1	4	2	2
502	2	6	45	-1	0.165	2	1	4	2	2
503	2	6	45	-1	0.1294	2	1	4	2	2
504	2	6	45	-1	0.0255	2	1	4	2	2
505	2	6	45	-1	0.0133	2	1	4	2	2
506	2	6	20	-1	0.9994	2	1	4	2	2
507	2	6	20	-1	0.9051	2	1	4	2	2
508	2	6	30	-1	0.231	2	1	4	2	2
509	2	6	30	-1	0.1936	2	1	4	2	2
510	2	6	30	-1	0.0885	2	1	4	2	2
511	2	6	30	-1	0.0469	2	1	4	2	2
512	2	6	128	-1	0.06	2	2	1	2	2
513	2	6	20	1	0.73	2	3	3	2	2
514	2	6	20	1	0.49	2	3	3	2	2
515	2	7	17	1	0.4117	1	3	3	2	2
516	2	7	17	1	0.4016	1	3	3	2	2
517	2	7	17	1	0.3836	1	3	3	2	2
518	2	7	17	1	0.2394	1	3	3	2	2
519	2	7	60	1	0.59	1	3	3	2	2
520	2	7	32	1	0.59	1	3	3	2	2
521	2	7	17	1	0.4262	1	3	3	2	2
522	2	7	17	1	0.4055	1	3	3	2	2
523	2	7	17	1	0.2989	1	3	3	2	2
524	2	7	24	1	0.65	1	3	4	2	2
525	2	7	24	1	0.4203	1	3	4	2	2
526	2	7	24	1	0.4158	1	3	4	2	2
527	2	7	24	1	0.4054	1	3	4	2	2
528	2	7	24	1	0.3489	1	3	4	2	2
529	2	7	24	1	0.3149	1	3	4	2	2
530	2	7	24	1	2.3984	1	3	4	2	2
531	2	7	21	1	0.5703	1	3	4	2	2
532	2	7	15	1	0.4399	1	3	4	2	2
533	2	7	21	1	0.26	1	3	4	2	2
534	2	7	15	1	0.2014	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
535	2	7	21	1	0.1442	1	3	4	2	2
536	2	7	21	1	0.1425	1	3	4	2	2
537	2	7	15	1	0.1408	1	3	4	2	2
538	2	7	15	1	0.1231	1	3	4	2	2
539	2	7	36	1	0.2831	1	3	4	2	2
540	2	7	36	1	0.032	2	3	4	2	2
541	2	7	8	1	0.4425	1	3	4	2	2
542	2	7	8	1	0.4021	1	3	4	2	2
543	2	7	8	1	0.3889	1	3	4	2	2
544	2	7	8	1	0.2597	1	3	4	2	2
545	2	7	12	1	3.02	1	3	4	2	2
546	2	7	12	1	1.23	1	3	4	2	2
547	2	7	41	1	0.5222	2	3	1	2	2
548	2	7	40	-1	0.4932	2	3	1	2	2
549	2	7	101	-1	0.05	2	3	1	2	2
550	2	7	121	-1	0.16	2	3	1	2	2
551	2	7	66	-1	0.3	2	3	3	2	2
552	2	7	32	1	0.4191	1	3	4	2	2
553	3	8	54	1	0.25	2	3	1	2	2
554	3	8	54	-1	0.0879	2	3	1	2	2
555	3	8	96	1	0.35	2	3	1	2	2
556	3	8	96	1	0.16	1	3	1	2	2
557	3	8	91	-1	0.9687	2	3	5	2	2
558	3	8	36	1	0.148	1	3	1	2	2
559	3	8	93	1	0.1085	2	3	1	2	2
560	3	8	93	1	0.0907	2	3	1	2	2
561	3	8	30	1	1.4083	1	3	4	2	2
562	3	8	30	1	0.3327	1	3	4	2	2
563	3	8	30	-1	0.2674	1	3	4	2	2
564	3	8	49	1	0.3911	1	3	1	2	2
565	3	8	50	1	0.1798	1	3	1	2	2
566	3	8	73	-1	0.43	2	3	1	2	2
567	3	8	60	-1	1.095	2	3	2	2	2
568	3	8	60	-1	0.9726	2	3	2	2	2
569	3	8	60	-1	0.9174	2	3	2	2	2
570	3	8	60	-1	0.3571	2	3	2	2	2
571	3	8	154	1	0.315	1	3	1	2	2
572	3	8	154	-1	0.016	2	3	1	2	2
573	3	8	35	1	0.788	1	3	4	2	2
574	3	8	35	1	0.32	1	3	4	2	2
575	3	8	102	-1	0.08	2	2	1	2	2
576	3	8	102	1	0.04	2	2	1	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
577	3	8	87	1	0.01	2		1	2	2
578	3	8	142	-1	0.02	2	2	1	2	2
579	3	8	233	-1	0.799	2	2	1	2	2
580	3	8	233	-1	0.459	2	2	1	2	2
581	3	8	24	1	0.4327	1	3	3	2	2
582	3	8	60	1	0.24	2	3	3	2	2
583	3	8	60	1	0.06	2	3	3	2	2
584	3	8	104	-1	0.87	2	3	2	2	2
585	3	8	104	1	0.63	2	3	2	2	2
586	3	8	20	1	0.2127	1	3	1	2	2
587	3	8	5	-1	0.803	1	3	5	2	2
588	3	8	88	-1	0.03	2	3	3	2	2
589	3	8	142	1	0.54	1	3	1	2	2
590	3	8	80	-1	2.6207	2	3	1	2	2
591	3	8	80	-1	2.4483	2	3	1	2	2
592	3	8	80	1	1.5172	2	3	1	2	2
593	3	8	80	1	1.3448	2	3	1	2	2
594	3	8	80	1	0.08	1	3	3	2	2
595	3	8	80	1	0.08	1	3	3	2	2
596	3	8	71	1	0.15	1	3	3	2	2
597	3	8	35	1	0.1485	1	3	3	2	2
598	3	8	36	-1	0.1239	2	3	3	2	2
599	3	8	110	-1	0.0592	2	3	5	2	2
600	3	8	110	-1	0.0452	2	3	5	2	2
601	3	8	110	-1	0.0409	2	3	5	2	2
602	3	8	110	-1	0.0217	2	3	5	2	2
603	3	8	79	1	0.29	2	3	2	2	2
604	3	8	58	1	0.4598	2	2	5	2	2
605	3	8	58	1	0.1712	2	2	5	2	2
606	3	8	119	1	0.075	2	3	5	2	2
607	3	8	66	1	0.17	2	1	1	2	2
608	3	8	169	1	0.3622	2	2	1	2	2
609	3	8	42	-1	0.3264	2	2	2	2	2
610	3	8	42	-1	0.0952	2	2	2	2	2
611	3	8	26	-1	0.26	2	3	5	2	2
612	3	8	69	1	0.157	2	3	5	2	2
613	3	8	87	-1	0.1999	2	3	5	2	2
614	3	8	94	-1	0.4	2	2	5	2	2
615	3	8	58	-1	0.001	2	1	5	2	2
616	3	8	35	-1	1.1457	2	3	5	2	2
617	3	8	30	-1	0.7525	2	3	5	2	2
618	3	8	36	-1	0.3176	2	3	5	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
619	3	8	53	-1	0.174	2	3	3	2	2
620	3	8	78	-1	0.04	2	3	1	2	2
621	3	8	62	-1	0.0488	2	3	5	2	2
622	3	8	137	1	0.43	2	3	1	2	2
623	3	8	137	1	0.1969	2	3	1	2	2
624	3	8	113	-1	0.7653	2	3	5	2	2
625	3	8	113	-1	0.7317	2	3	5	2	2
626	3	8	113	-1	0.4992	2	3	5	2	2
627	3	8	113	-1	0.3323	2	3	5	2	2
628	3	8	153	-1	0.44	2	2	1	2	2
629	3	8	30	1	0.2522	2	3	2	2	2
630	3	8	25	-1	0.5106	2	2	1	2	2
631	3	8	25	1	0.3269	2	2	1	2	2
632	3	8	25	-1	0.3233	2	2	1	2	2
633	3	8	25	-1	0.034	2	2	1	2	2
634	3	8	23	1	0.2413	2	3	4	2	2
635	3	8	23	1	0.2049	1	3	4	2	2
636	3	8	15	1	0.466	1	3	5	2	2
637	3	8	30	1	0.1868	1	3	4	2	2
638	3	8	30	1	0.1843	1	3	4	2	2
639	3	8	30	1	0.0745	1	3	4	2	2
640	3	8	30	1	0.3496	1	3	4	2	2
641	3	8	8	1	0.2809	1	3	4	2	2
642	3	8	145	1	0.1127	2	3	1	2	2
643	3	8	145	1	0.078	2	3	1	2	2
644	3	9	54	-1	0.1361	2	3	1	2	2
645	3	9	96	1	0.064	2	3	1	2	2
646	3	9	24	1	0.255	1	1	1	2	2
647	3	9	24	-1	0.155	2	1	1	2	2
648	3	9	80	-1	0.1477	2	3	2	2	2
649	3	9	80	1	0.1142	2	3	2	2	2
650	3	9	34	-1	0.2273	2	3	1	2	2
651	3	9	16	-1	0.214	2	3	1	2	2
652	3	9	59	-1	0.2337	2	3	2	2	2
653	3	9	59	-1	0.1748	1	3	2	2	2
654	3	9	38	1	0.1476	2	3	2	2	2
655	3	9	30	1	1.129	2	3	1	2	2
656	3	9	29	1	0.2526	2	3	1	2	2
657	3	9	98	-1	0.07	2	3	1	2	2
658	3	9	98	1	0.05	2	3	1	2	2
659	3	9	53	-1	0.1233	2	3	1	2	2
660	3	9	31	1	0.1152	2	3	1	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
661	3	9	20	-1	0.2785	2	2	2	2	2
662	3	9	22	-1	0.9994	2	3	1	2	2
663	3	9	22	-1	0.5955	2	3	1	2	2
664	3	9	25	-1	0.7818	2	3	1	2	2
665	3	9	25	-1	0.0338	2	3	1	2	2
666	3	9	18	-1	0.5395	2	3	1	2	2
667	3	9	18	-1	0.3108	2	3	1	2	2
668	3	9	18	1	0.5375	2	3	1	2	2
669	3	9	18	1	0.4984	2	3	1	2	2
670	3	9	56	-1	0.3714	2	2	3	2	2
671	3	9	56	1	0.137	2	2	3	2	2
672	3	9	57	-1	0.4157	2	2	3	2	2
673	3	9	57	1	0.0362	2	2	3	2	2
674	3	9	36	-1	0.21	1	3	1	2	2
675	3	9	60	1	0.9	1	2	2	2	2
676	3	9	60	1	0.53	1	2	2	2	2
677	3	9	60	1	0.2596	1	2	2	2	2
678	3	9	53	1	0.67	1	2	2	2	2
679	3	9	53	1	0.5	1	2	2	2	2
680	3	9	53	1	0.05	1	2	2	2	2
681	3	9	34	-1	0.7	2	2	2	2	2
682	3	9	78	-1	0.8	2	2	2	2	2
683	3	9	78	-1	0.6	2	2	2	2	2
684	3	9	93	1	0.0355	2	3	1	2	2
685	3	9	93	1	0.0461	2	3	1	2	2
686	3	9	49	1	0.4005	1	3	1	2	2
687	3	9	68	-1	0.42	2	3	1	2	2
688	3	9	73	-1	0.117	2	3	1	2	2
689	3	9	102	-1	0.07	2	2	1	2	2
690	3	9	126	-1	0.1809	2	2	3	2	2
691	3	9	126	1	0.1779	2	2	3	2	2
692	3	9	30	1	0.393	1	3	5	2	2
693	3	9	104	-1	0.57	2	3	2	2	2
694	3	9	104	1	0.49	2	3	2	2	2
695	3	9	5	-1	0.817	1	3	5	2	2
696	3	9	88	1	0.077	1	3	3	2	2
697	3	9	219	-1	0.076	2	3	1	2	2
698	3	9	219	-1	0.046	2	3	1	2	2
699	3	9	80	-1	2.119	2	3	1	2	2
700	3	9	80	-1	1.8095	2	3	1	2	2
701	3	9	80	1	0.4048	2	3	1	2	2
702	3	9	80	1	0.0952	2	3	1	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
703	3	9	80	1	0.41	1	3	3	2	2
704	3	9	80	1	0.1	1	3	3	2	2
705	3	9	36	1	0.21	1	3	3	2	2
706	3	9	35	-1	0.0997	1	3	3	2	2
707	3	9	71	1	0.04	2	3	3	2	2
708	3	9	41	-1	0.1259	2	2	1	2	2
709	3	9	216	-1	0.13	2	3	1	2	2
710	3	9	216	1	0.095	1	3	1	2	2
711	3	9	74	-1	0.01	2	3	2	2	2
712	3	9	74	-1	0.001	2	3	2	2	2
713	3	9	110	-1	0.0926	2	3	5	2	2
714	3	9	110	-1	0.0224	2	3	5	2	2
715	3	9	79	1	0.2	2	3	2	2	2
716	3	9	79	1	0.17	2	3	2	2	2
717	3	9	66	1	0.29	2	1	1	2	2
718	3	9	40	-1	0.3291	1	1	2	2	2
719	3	9	36	-1	0.6799	2	3	3	2	2
720	3	9	35	-1	0.4545	2	3	3	2	2
721	3	9	35	-1	0.4207	2	3	3	2	2
722	3	9	45	-1	0.3784	2	3	3	2	2
723	3	9	46	-1	0.3	2	3	3	2	2
724	3	9	36	-1	0.2579	2	3	3	2	2
725	3	9	36	-1	0.2344	2	3	3	2	2
726	3	9	35	-1	0.2109	2	3	3	2	2
727	3	9	45	-1	0.1951	2	3	3	2	2
728	3	9	46	-1	0.1472	2	3	3	2	2
729	3	9	46	-1	0.1222	2	3	3	2	2
730	3	9	45	-1	0.0462	2	3	3	2	2
731	3	9	94	-1	0.17	2	2	5	2	2
732	3	9	58	-1	0.404	2	1	5	2	2
733	3	9	72	-1	0.0978	2	1	1	2	2
734	3	9	44	1	0.3279	1	3	5	2	2
735	3	9	788	-1	0.206	2	2	3	2	2
736	3	9	73	-1	0.79	2	2	3	2	2
737	3	9	54	1	0.2242	2	3	2	2	2
738	3	9	54	1	0.0893	2	3	2	2	2
739	3	9	54	-1	0.1961	2	2	2	2	2
740	3	9	153	1	0.046	2	2	2	2	2
741	3	9	49	-1	0.78	2	3	1	2	2
742	3	9	55	-1	0.67	2	3	1	2	2
743	3	9	132	1	0.056	2	3	1	2	2
744	3	9	96	1	1.0838	2	2	1	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
745	3	9	96	1	0.3322	2	2	1	2	2
746	3	9	31	1	0.4	1	3	5	2	2
747	3	9	30	1	0.2724	1	3	4	2	2
748	3	9	8	1	0.4115	1	3	4	2	2
749	3	9	63	1	0.122	2	3	1	2	2
750	3	10	26	1	1.02	2	3	1	2	2
751	3	10	111	1	0.72	2	2	1	2	2
752	3	10	111	-1	0.44	2	2	1	2	2
753	3	10	80	1	0.78	2	3	5	2	2
754	3	10	12	1	0.367	1	3	4	2	2
755	3	10	12	1	0.3514	1	3	4	2	2
756	3	10	12	1	0.2605	1	3	4	2	2
757	3	10	66	-1	0.2472	1	3	3	2	2
758	3	10	71	1	0.1236	1	3	3	2	2
759	3	10	137	-1	0.033	2	3	3	2	2
760	3	10	151	-1	0.1	2	3	3	2	2
761	3	10	143	-1	0.12	2	3	3	2	2
762	3	10	73	-1	0.12	2	3	1	2	2
763	3	10	73	-1	0.07	2	3	1	2	2
764	3	10	74	-1	0.17	2	3	2	2	2
765	3	10	74	-1	0.045	2	3	2	2	2
766	3	10	74	-1	0.038	2	3	2	2	2
767	3	10	74	-1	0.004	2	3	2	2	2
768	3	10	66	1	0.31	2	1	1	2	2
769	3	10	137	-1	0.033	2	3	3	2	2
770	3	10	91	-1	0.0654	2	2	1	2	2
771	3	10	222	-1	1.5572	2	3	5	2	2
772	3	10	186	-1	0.0704	2	3	3	2	2
773	3	10	6	1	0.4374	1	3	4	2	2
774	3	10	6	1	0.3652	1	3	4	2	2
775	3	10	30	1	0.4037	1	3	4	2	2
776	3	10	8	1	0.3662	1	3	4	2	2
777	3	10	5	1	3.9867	1	3	5	2	2
778	3	10	25	1	0.18	2	3	1	2	2
779	3	11	10	1	0.3285	1	3	4	2	2
780	3	11	35	1	0.4132	1	3	5	2	2
781	3	11	60	1	0.2	2	3	3	2	2
782	3	11	60	1	0.03	2	3	3	2	2
783	3	11	24	1	0.223	1	3	5	2	2
784	3	11	24	1	0.165	1	3	5	2	2
785	3	11	12	1	0.4117	1	3	4	2	2
786	3	11	12	1	0.408	1	3	4	2	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
787	3	11	12	1	0.3495	1	3	4	2	2
788	3	11	12	1	0.1485	1	3	4	2	2
789	3	11	142	1	0.44	1	3	1	2	2
790	3	11	142	1	0.43	1	3	1	2	2
791	3	11	7	-1	0.3894	1	3	4	2	2
792	3	11	7	1	0.3882	1	3	4	2	2
793	3	11	32	-1	0.44	1	3	5	2	2
794	3	11	32	-1	0.23	1	3	5	2	2
795	3	11	116	1	0.4482	2	1	3	2	2
796	3	11	108	1	0.4158	2	1	3	2	2
797	3	11	41	-1	0.31	1	3	5	2	2
798	3	11	6	1	0.385	1	3	4	2	2
799	3	11	12	1	0.3846	1	3	4	2	2
800	3	11	12	1	0.2639	1	3	4	2	2
801	3	11	15	1	0.3632	1	3	5	2	2
802	3	11	15	1	0.3119	1	3	5	2	2
803	3	11	15	1	0.2571	1	3	5	2	2
804	3	11	24	1	0.405	1	3	4	2	2
805	3	11	12	1	0.9967	1	3	5	2	2
806	4	12	9	1	0.4372	1	3	4	1	2
807	4	12	9	1	0.3638	1	3	4	1	2
808	4	12	9	1	0.1018	1	3	4	1	2
809	4	12	24	1	0.1925	1	3	3	1	2
810	4	12	24	1	0.0906	1	3	3	1	2
811	4	12	7	1	0.4101	1	3	4	1	2
812	4	12	7	1	0.3984	1	3	4	1	2
813	4	12	17	1	0.1207	1	3	5	1	2
814	4	12	11	1	0.03	1	3	4	1	2
815	4	13	9	1	0.4379	1	3	4	1	2
816	4	13	9	1	0.3711	1	3	4	1	2
817	4	13	9	1	0.0961	1	3	4	1	2
818	4	13	30	1	0.4293	1	3	5	1	2
819	4	15	32	-1	0.1065	1		4	1	2
820	4	15	33	1	0.3857	1	3	2	1	2
821	4	15	37	1	1	1	3	4	1	2
822	4	15	37	1	0.56	1	3	4	1	2
823	4	15	9	1	0.3492	1	3	4	1	2
824	4	15	9	1	0.276	1	3	4	1	2
825	4	15	9	1	0.0056	1	3	4	1	2
826	4	15	24	1	0.1736	1	3	3	1	2
827	4	15	35	1	0.63	1	3	4	1	2
828	4	15	35	1	0.293	1	3	4	1	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
829	4	15	30	1	0.624	1	3	4	1	2
830	4	15	30	1	0.272	1	3	4	1	2
831	4	15	30	1	0.18	2	3	4	1	2
832	4	15	30	1	0.004	2	3	4	1	2
833	4	15	36	1	0.687	1	3	4	1	2
834	4	15	36	1	0.575	1	3	4	1	2
835	4	15	36	1	0.525	1	3	4	1	2
836	4	15	36	1	0.289	1	3	4	1	2
837	4	15	36	1	0.166	1	3	4	1	2
838	4	15	36	1	0.007	1	3	4	1	2
839	4	15	36	1	0.002	1	3	4	1	2
840	4	15	36	1	0.002	1	3	4	1	2
841	4	15	9	1	0.3932	1	3	3	1	2
842	4	15	9	1	0.3548	1	3	3	1	2
843	4	15	17	1	0.3794	1	3	3	1	2
844	4	15	17	1	0.3505	1	3	3	1	2
845	4	15	17	1	0.2351	1	3	3	1	2
846	4	15	30	1	0.3452	1	3	5	1	2
847	4	15	54	1	0.44	1	3	4	1	2
848	4	15	32	1	0.3736	1	3	4	1	2
849	4	15	32	1	0.3454	2	3	4	1	2
850	4	15	32	1	0.1305	1	3	4	1	2
851	4	15	32	1	0.0859	2	3	4	1	2
852	4	15	48	-1	0.075	2	3	5	1	2
853	4	15	12	1	0.4129	1	3	4	1	2
854	4	15	12	1	0.3973	1	3	4	1	2
855	4	15	12	1	0.4129	1	3	4	1	2
856	4	15	24	1	0.3231	1	3	2	1	2
857	4	15	24	1	0.2855	1	3	2	1	2
858	4	15	24	-1	0.2717	1	3	2	1	2
859	4	15	24	1	0.2321	1	3	4	1	2
860	4	15	24	1	0.1945	1	3	4	1	2
861	4	15	24	1	0.3327	1	3	4	1	2
862	4	15	24	1	0.2454	1	3	4	1	2
863	4	15	18	-1	0.291	1	3	4	1	2
864	4	15	24	1	0.56	1	3	5	1	2
865	4	15	24	1	0.4	1	3	5	1	2
866	4	15	24	1	0.04	1	3	5	1	2
867	4	15	11	1	0.11	1	3	4	1	2
868	4	16	24	1	0.3383	1	3	3	1	1
869	4	16	48	-1	0.068	2	3	5	1	1
870	4	16	12	1	1.4635	1	3	4	1	1

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
871	4	16	12	1	0.6145	1	3	4	1	1
872	4	16	12	1	0.621	1	3	4	1	1
873	4	16	51	1	0.2	1	3	4	1	1
874	4	16	22	1	0.7996	1	3	3	1	1
875	4	16	23	1	0.5695	1	3	3	1	1
876	5	17	30	1	0.8962	1	3	4	1	2
877	5	17	30	1	0.3816	1	3	4	1	2
878	5	17	30	1	0.2338	1	3	4	1	2
879	5	17	30	1	0.1767	1	3	5	1	2
880	5	17	31	-1	0.13	2	3	4	1	2
881	5	17	7	1	0.4163	1	3	2	1	2
882	5	17	7	1	0.3433	1	3	2	1	2
883	5	17	40	1	0.4451	1	3	5	1	2
884	5	17	11	1	0.3856	1	3	5	1	2
885	5	17	11	1	0.2429	1	3	5	1	2
886	5	17	12	1	0.1939	1	3	5	1	2
887	5	17	12	1	0.1688	1	3	5	1	2
888	5	17	15	1	0.3262	1	3	5	1	2
889	5	17	24	1	0.1854	1	3	4	1	2
890	5	17	12	1	1.7763	1	3	5	1	2
891	5	17	12	1	0.9071	1	3	5	1	2
892	5	17	31	1	0.43	1	3	5	1	2
893	5	17	32	1	0.3312	1		2	1	2
894	5	17	32	1	0.2074	1		2	1	2
895	5	17	32	1	0.0944	1		2	1	2
896	5	17	32	1	0.0311	1		2	1	2
897	5	17	30	1	0.1841	1	3	4	1	2
898	5	18	24	1	0.2251	1	3	5	1	2
899	5	18	24	1	0.187	1	3	5	1	2
900	5	18	48	1	0.1195	1	3	5	1	2
901	5	18	8	1	0.415	1	3	4	1	2
902	5	18	32	1	0.3152	1	3	4	1	2
903	5	18	49	-1	0.1729	2	1	2	1	2
904	5	18	45	1	0.52	1	3	4	1	2
905	5	18	7	1	0.6126	1	3	5	1	2
906	5	18	23	1	0.2934	1	3	4	1	2
907	5	18	14	1	0.3578	1	3	5	1	2
908	5	18	14	1	0.3528	1	3	5	1	2
909	5	18	18	-1	0.1476	2	3	4	1	2
910	5	19	32	1	0.8	1	3	4	1	2
911	5	19	49	-1	0.0014	2	1	2	1	2
912	5	19	20	1	0.2966	1	3	4	1	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
913	5	19	23	1	0.3951	1	3	4	1	2
914	5	19	7	1	0.3741	1	3	2	1	2
915	5	20	60	1	0.2628	2	3	2	1	2
916	5	20	60	1	0.26	2	3	2	1	2
917	5	20	60	1	0.165	2	3	2	1	2
918	5	20	60	-1	0.0273	2	3	2	1	2
919	5	20	8	1	0.3301	1	3	4	1	2
920	5	20	32	1	0.68	1	3	4	1	2
921	5	20	49	1	0.0698	2	1	2	1	2
922	5	20	7	1	0.1832	1	3	5	1	2
923	5	20	20	1	0.2575	1	3	4	1	2
924	5	20	23	1	0.3792	1	3	4	1	2
925	5	20	7	1	0.296	1	3	2	1	2
926	5	20	65	1	0.29	2	3	4	1	2
927	5	20	11	1	0.3116	1	3	5	1	2
928	5	20	11	1	0.1835	1	3	5	1	2
929	5	20	14	1	0.3132	1	3	5	1	2
930	5	20	31	1	0.31	1	3	5	1	2
931	5	20	16	1	0.2127	1	3	4	1	2
932	5	20	30	1	0.0909	1	3	4	1	2
933	5	20	18	-1	0.2403	2	3	4	1	2
934	5	20	8	1	0.159	1	3	4	1	2
935	5	20	5	1	2.2203	1	3	5	1	2
936	5	21	32	1	0.52	1	3	4	1	2
937	5	21	32	1	0.2077	2	3	4	1	2
938	5	21	31	-1	0.1649	2	3	4	1	2
939	5	21	49	1	0.2248	2	1	2	1	2
940	5	21	7	1	0.602	1	3	5	1	2
941	5	21	7	1	0.364	1	3	2	1	2
942	5	21	65	1	0.39	2	3	4	1	2
943	5	21	15	1	0.263	1	3	5	1	2
944	5	21	11	1	0.1908	1	3	5	1	2
945	5	21	11	1	0.1609	1	3	5	1	2
946	5	21	14	1	0.2567	1	3	5	1	2
947	5	21	18	1	0.0009	2	3	4	1	2
948	5	22	31	-1	0.4044	2	3	4	1	2
949	5	22	65	1	0.06	2	3	4	1	2
950	5	22	40	1	0.4943	1	3	5	1	2
951	5	22	15	1	0.489	1	3	5	1	2
952	5	22	14	1	0.3541	1	3	5	1	2
953	5	22	14	1	0.3111	1	3	5	1	2
954	5	22	12	1	0.9484	1	3	5	1	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES
955	5	22	12	1	0.5471	1	3	5	1	2
956	5	22	18	1	0.1476	2	3	4	1	2
957	5	23	31	-1	0.17	2	3	4	1	2
958	5	23	40	1	0.6521	1	3	5	1	2
959	5	23	14	1	0.3665	1	3	5	1	2
960	5	23	14	1	0.3293	1	3	5	1	2
961	5	23	18	1	0.22	2	3	4	1	2
962	5	24	20	-1	1.4611	1	3	1	1	2
963	5	24	20	-1	0.9357	1	3	1	1	2
964	5	24	20	-1	0.9023	1	3	1	1	2
965	5	24	15	1	2.467	1	3	5	1	2
966	5	24	15	1	1.239	1	3	5	1	2
967	5	24	15	1	0.8493	1	3	5	1	2
968	5	24	15	1	0.816	1	3	5	1	2
969	5	25	24	1	0.193	1	3	5	1	2
970	5	25	24	1	0.177	1	3	5	1	2
971	5	25	24	1	0.16	1	3	4	1	2
972	5	25	5	1	0.658	1	3	5	1	2
973	5	25	5	1	0.603	1	3	5	1	2
974	5	25	35	1	0.42	1	3	4	1	2
975	5	25	35	1	0.2652	2	3	4	1	2
976	5	25	12	1	0.2822	1	3	4	1	2

APPENDIX D

SELF-RATING CODEBOOK

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES	SRating
553	3	54	1	0.25	1	592	3	80	1	1.5172	2
554	3	54	-1	0.0879	1	593	3	80	1	1.3448	2
555	3	96	1	0.35	1	594	3	80	1	0.08	2
556	3	96	1	0.16	1	595	3	80	1	0.08	2
557	3	91	-1	0.9687	1	596	3	71	1	0.15	1
558	3	36	1	0.148	2	597	3	35	1	0.1485	1
559	3	93	1	0.1085	1	598	3	36	-1	0.1239	1
560	3	93	1	0.0907	1	599	3	110	-1	0.0592	1
561	3	30	1	1.4083	1	600	3	110	-1	0.0452	1
562	3	30	1	0.3327	1	601	3	110	-1	0.0409	1
563	3	30	-1	0.2674	1	602	3	110	-1	0.0217	1
564	3	49	1	0.3911	1	603	3	79	1	0.29	1
565	3	50	1	0.1798	1	604	3	58	1	0.4598	1
566	3	73	-1	0.43	1	605	3	58	1	0.1712	1
567	3	60	-1	1.095	1	606	3	119	1	0.075	1
568	3	60	-1	0.9726	1	607	3	66	1	0.17	2
569	3	60	-1	0.9174	1	608	3	169	1	0.3622	1
570	3	60	-1	0.3571	1	609	3	42	-1	0.3264	1
571	3	154	1	0.315	1	610	3	42	-1	0.0952	1
572	3	154	-1	0.016	1	611	3	26	-1	0.26	1
573	3	35	1	0.788	1	612	3	69	1	0.157	1
574	3	35	1	0.32	1	613	3	87	-1	0.1999	1
575	3	102	-1	0.08	2	614	3	94	-1	0.4	1
576	3	102	1	0.04	2	615	3	58	-1	0.001	1
577	3	87	1	0.01	1	616	3	35	-1	1.1457	1
578	3	142	-1	0.02	1	617	3	30	-1	0.7525	1
579	3	233	-1	0.799	2	618	3	36	-1	0.3176	1
580	3	233	-1	0.459	2	619	3	53	-1	0.174	1
581	3	24	1	0.4327	1	620	3	78	-1	0.04	
582	3	60	1	0.24	1	621	3	62	-1	0.0488	1
583	3	60	1	0.06	1	622	3	137	1	0.43	1
584	3	104	-1	0.87	1	623	3	137	1	0.1969	1

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES	SRating
585	3	104	1	0.63	1	624	3	113	-1	0.7653	1
586	3	20	1	0.2127	1	625	3	113	-1	0.7317	1
587	3	5	-1	0.803	1	626	3	113	-1	0.4992	1
588	3	88	-1	0.03	1	627	3	113	-1	0.3323	1
589	3	142	1	0.54	1	628	3	153	-1	0.44	2
590	3	80	-1	2.6207	2	629	3	30	1	0.2522	1
591	3	80	-1	2.4483	2	630	3	25	-1	0.5106	1
630	3	25	-1	0.5106	1	673	3	57	1	0.0362	1
631	3	25	1	0.3269	1	674	3	36	-1	0.21	2
632	3	25	-1	0.3233	1	675	3	60	1	0.9	1
633	3	25	-1	0.034	1	676	3	60	1	0.53	1
636	3	15	1	0.466	1	677	3	60	1	0.2596	1
637	3	30	1	0.1868	1	678	3	53	1	0.67	1
638	3	30	1	0.1843	1	679	3	53	1	0.5	1
639	3	30	1	0.0745	1	680	3	53	1	0.05	1
640	3	30	1	0.3496	1	681	3	34	-1	0.7	1
641	3	8	1	0.2809	1	682	3	78	-1	0.8	1
642	3	145	1	0.1127	1	683	3	78	-1	0.6	1
643	3	145	1	0.078	1	684	3	93	1	0.0355	1
644	3	54	-1	0.1361	1	685	3	93	1	0.0461	1
645	3	96	1	0.064	1	686	3	49	1	0.4005	1
646	3	24	1	0.255	1	687	3	68	-1	0.42	1
647	3	24	-1	0.155	1	688	3	73	-1	0.117	1
648	3	80	-1	0.1477	1	689	3	102	-1	0.07	2
649	3	80	1	0.1142	1	690	3	126	-1	0.1809	1
650	3	34	-1	0.2273	1	691	3	126	1	0.1779	1
651	3	16	-1	0.214	1	692	3	30	1	0.393	1
652	3	59	-1	0.2337	1	693	3	104	-1	0.57	1
653	3	59	-1	0.1748	1	694	3	104	1	0.49	1
654	3	38	1	0.1476	1	695	3	5	-1	0.817	1
655	3	30	1	1.129	1	696	3	88	1	0.077	1
656	3	29	1	0.2526	1	697	3	219	-1	0.076	2
657	3	98	-1	0.07	1	698	3	219	-1	0.046	2
658	3	98	1	0.05	1	699	3	80	-1	2.119	2
659	3	53	-1	0.1233	1	700	3	80	-1	1.8095	2
660	3	31	1	0.1152	1	701	3	80	1	0.4048	2
661	3	20	-1	0.2785	1	702	3	80	1	0.0952	2
662	3	22	-1	0.9994	1	703	3	80	1	0.41	2
663	3	22	-1	0.5955	1	704	3	80	1	0.1	2
664	3	25	-1	0.7818	1	705	3	36	1	0.21	2
665	3	25	-1	0.0338	1	706	3	35	-1	0.0997	2
666	3	18	-1	0.5395	1	707	3	71	1	0.04	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES	SRating
667	3	18	-1	0.3108	1	708	3	41	-1	0.1259	1
668	3	18	1	0.5375	1	709	3	216	-1	0.13	1
669	3	18	1	0.4984	1	710	3	216	1	0.095	1
670	3	56	-1	0.3714	1	711	3	74	-1	0.01	2
671	3	56	1	0.137	1	712	3	74	-1	0.001	2
672	3	57	-1	0.4157	1	713	3	110	-1	0.0926	1
1	3	57	1	0.0362		714	3	110	-1	0.0224	1
715	3	79	1	0.2	1	757	3	66	-1	0.2472	2
716	3	79	1	0.17	1	758	3	71	1	0.1236	2
717	3	66	1	0.29	2	759	3	137	-1	0.033	2
718	3	40	-1	0.3291	1	760	3	151	-1	0.1	2
719	3	36	-1	0.6799	2	761	3	143	-1	0.12	2
720	3	35	-1	0.4545	2	762	3	73	-1	0.12	2
721	3	35	-1	0.4207	2	763	3	73	-1	0.07	2
722	3	45	-1	0.3784	2	764	3	74	-1	0.17	2
723	3	46	-1	0.3	2	765	3	74	-1	0.045	2
724	3	36	-1	0.2579	2	766	3	74	-1	0.038	2
725	3	36	-1	0.2344	2	767	3	74	-1	0.004	2
726	3	35	-1	0.2109	2	768	3	66	1	0.31	2
727	3	45	-1	0.1951	2	769	3	137	-1	0.033	2
728	3	46	-1	0.1472	2	770	3	91	-1	0.0654	2
729	3	46	-1	0.1222	2	771	3	222	-1	1.5572	2
730	3	45	-1	0.0462	2	772	3	186	-1	0.0704	2
731	3	94	-1	0.17	1	773	3	6	1	0.4374	2
732	3	58	-1	0.404	1	774	3	6	1	0.3652	2
733	3	72	-1	0.0978	1	775	3	30	1	0.4037	1
734	3	44	1	0.3279	2	776	3	8	1	0.3662	1
735	3	788	-1	0.206	1	777	3	5	1	3.9867	1
736	3	73	-1	0.79	1	778	3	25	1	0.18	2
737	3	54	1	0.2242	1	779	3	10	1	0.3285	2
738	3	54	1	0.0893	1	780	3	35	1	0.4132	2
739	3	54	-1	0.1961	1	781	3	60	1	0.2	2
740	3	153	1	0.046	1	782	3	60	1	0.03	2
741	3	49	-1	0.78	1	783	3	24	1	0.223	2
742	3	55	-1	0.67	1	784	3	24	1	0.165	2
743	3	132	1	0.056	2	785	3	12	1	0.4117	2
744	3	96	1	1.0838	1	786	3	12	1	0.408	2
745	3	96	1	0.3322	1	787	3	12	1	0.3495	2
746	3	31	1	0.4	1	788	3	12	1	0.1485	2
747	3	30	1	0.2724	1	789	3	142	1	0.44	2
748	3	8	1	0.4115	1	790	3	142	1	0.43	2
749	3	63	1	0.122	1	791	3	7	-1	0.3894	2

StudyID	Code	(n=)	ESDirection	ES	SRating	StudyID	Code	(n=)	ESDirection	ES	SRating
750	3	26	1	1.02	2	792	3	7	1	0.3882	2
751	3	111	1	0.72	2	793	3	32	-1	0.44	2
752	3	111	-1	0.44	2	794	3	32	-1	0.23	2
753	3	80	1	0.78	2	795	3	116	1	0.4482	2
754	3	12	1	0.367	2	796	3	108	1	0.4158	2
755	3	12	1	0.3514	2	797	3	41	-1	0.31	2
756	3	12	1	0.2605	2	798	3	6	1	0.385	2
805	3	12	1	0.9967	2						

REFERENCES

Aasman, J., Mulder, G., & Mulder, L. J. (1987). Operator effort and the measurement of heart-rate variability. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 29*(2), 161-170. doi:10.1177/001872088702900204

Abdul-Rahman, S. S., & Du Boulay, B. (2014). Learning programming via worked-examples: Relation of learning styles to cognitive load. *Computers in Human Behavior, 30*, 286-298. doi:10.1016/j.chb.2013.09.007

Adcock, A. B. (2004). The interaction of learner expertise and instructional role of a pedagogical agent on learner perception of agent, perceived cognitive load and task performance (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3137776)

Ahlstrom, U., & Friedman-Berg, F. J. (2006). Using eye movement activity as a correlate of cognitive workload. *International Journal of Industrial Ergonomics, 36*(7), 623-636. doi:10.1016/j.ergon.2006.04.002

Ahn, J. (2010). The effect of accents on cognitive load and achievement: The relationship between students' accent perception and accented voice instructions in students' achievement (Doctoral dissertation). Available from ERIC. (UMI No. 3423421)

Alban, A. D. (2003). Neuropsychological malingering and cognitive load: Disrupting deception of neuropsychological measures through cognitive overload (Doctoral dissertation). *Dissertation Abstracts International, 63,* 4358.

Allen, C. G. (2011). The effects of visual complexity on cognitive load as influenced by field dependency and spatial ability (Doctoral dissertation). New York University, US.

Althaus, M., Mulder, L. J., Mulder, G., Van Roon, A. M., & Minderaa, R. B. (1998). Influence of respiratory activity on the cardiac response pattern to mental effort. *Psychophysiology, 35*(04), 420-430. doi:10.1111/1469-8986.3540420

Al-Shehri, S., & Gitsaki, C. (2010). Online reading: A preliminary study of the impact of integrated and split-attention formats on L2 students' cognitive load. *ReCALL, 22*(3), 356-375. doi:10.1017/S0958344010000212

Amadieu, F., Mariné, C., & Laimay, C. (2011). The attention-guiding effect and cognitive load in the comprehension of animations. *Computers in Human*

Behavior, 27(1), 36-40. doi:10.1016/j.chb.2010.05.009

Amadieu, F., Van Gog, T., Paas, F., Tricot, A., & Mariné, C. (2009). Effects of prior knowledge and concept-map structure on disorientation, cognitive load, and learning. *Learning and Instruction, 19*(5), 376-386. doi:10.1016/j.learninstruc.2009.02.005

Andersson, G., Hagman, J., Talianzadeh, R., Svedberg, A., & Larsen, H. C. (2002). Effect of cognitive load on postural control. *Brain Research Bulletin, 58*(1), 135-139. doi:10.1016/S0361-9230(02)00770-0

Angeli, C. (2013). Examining the effects of field dependence–independence on learners' problem-solving performance and interaction with a computer modeling tool: Implications for the design of joint cognitive systems. *Computers & Education, 62*, 221-230. doi:10.1016/j.compedu.2012.11.002

Angeli, C., Valanides, N., & Kirschner, P. (2009). Field dependence–independence and instructional-design effects on learners' performance with a computer-modeling tool. *Computers in Human Behavior, 25*(6), 1355-1366. doi:10.1016/j.chb.2009.05.010

Angelone, B. L. (2003). Incidental change detection and short-term memory load in a dual-task paradigm (Doctoral dissertation). Kent State University, US.

Antonenko, P. D., & Niederhauser, D. S. (2010). The influence of leads on cognitive load and learning in a hypertext environment. *Computers in Human Behavior, 26*(2), 140-150. doi:10.1016/j.chb.2009.10.014

Antonenko, P., Paas, F., Grabner, R., & van Gog, T. (2010). Using electroencephalography to measure cognitive load. *Educational Psychology Review, 22*(4), 425-438. doi:10.1007/s10648-010-9130-y

Ayaz, H., Shewokis, P. A., Bunce, S., Izzetoglu, K., Willems, B., & Onaral, B. (2012). Optical brain monitoring for operator training and mental workload assessment. *Neuroimage, 59*(1), 36-47. doi:10.1016/j.neuroimage.2011.06.023

Ayres, P. L. (2001). Systematic mathematical errors and cognitive load. *Contemporary Educational Psychology, 26*(2), 227-248. doi:10.1006/ceps.2000.1051

Ayres, P. (2006a). Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Applied Cognitive Psychology, 20*, 287-298. doi:10.1002/acp.1245

Ayres, P. (2006b). Using subjective measures to detect variations of intrinsic cognitive load within problems. *Learning and Instruction, 16*(5), 389-400. doi:10.1016/j.learninstruc.2006.09.001

Ayres, P. (2013). Can the isolated-elements strategy be improved by targeting points of high cognitive load for additional practice? *Learning and Instruction, 23,* 115-124. doi:10.1016/j.learninstruc.2012.08.002

Ayres, P. & Paas, F. (2012). Cognitive Load Theory: New Directions and Challenges. *Applied Cognitive Psychology, 26*, 827-832

Ayres, P. & Sweller, J. (1990). Locus of difficulty in multistage mathematics problems. *The American Journal of Psychology, 103*(2), 167-193. doi:10.2307/1423141

Baccino, T., & Manunta, Y. (2005). Eye-fixation-related potentials: Insight into parafoveal processing. *Journal of Psychophysiology, 19*(3), 204-215. doi:10.1027/0269-8803.19.3.204

Backs, R. W. (1995). Going beyond heart rate: autonomic space and cardiovascular assessment of mental workload. *The International Journal of Aviation Psychology, 5*(1), 25-48. doi:10.1207/s15327108ijap0501_3

Baddeley, A.D. & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation, 8, 47-89*. doi:10.1016/S0079-7421(08)60452-1

Bannert, M. (2002). Managing cognitive load—recent trends in cognitive load theory. *Learning and Instruction, 12*(1), 139-146

Barker, L. A. (2012). Defining the parameters of incidental learning on a serial reaction time (SRT) task: Do conscious rules apply? *Brain Sciences, 2*(4), 769-789. doi:10.3390/brainsci2040769

Barrouillet, P., Bernardin, S., Portrat, S., Vergauwe, E., & Camos, V. (2007). Time and cognitive load in working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(3), 570-585. doi:10.1037/0278-7393.33.3.570

Bartolucci, A. A., & Hillegass, W. B. (2010). Overview, strengths, and limitations of systematic reviews and meta-analyses. In *Evidence-Based Practice: Toward Optimizing Clinical Outcomes* (pp. 17-33). Springer Berlin Heidelberg.

Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin, 91*(2), 276-292. doi:10.1037/0033-2909.91.2.276

Beckmann, J.F. (2010). Taming a beast of burden – On some issues with the conceptualization and operationalization of cognitive load. *Learning and Instruction, 20*, 250-264. doi:10.1016/j.learninstruc.2009.02.024

Beers, P. J., Boshuizen, H. P., Kirschner, P. A., Gijselaers, W., & Westendorp, J. (2008). Cognitive load measurements and stimulated recall interviews for studying the effects of information and communications technology. *Educational Technology Research and Development*, *56*(3), 309-328. doi:10.1007/s11423-006-9020-7

Bennett, D. A. (2001) How can I deal with missing data in my study? *Australian and New Zealand Journal of Public Health, 25*(5):464–469. doi:10.1111/j.1467-842X.2001.tb00294.x

Bobis, J., Sweller, J., & Cooper, M. (1993). Cognitive load effects in a primary-school geometry task. *Learning and Instruction, 3*(1), 1-21. doi:10.1016/S0959-4752(09)80002-9

Boles, D. B., Bursk, J. H., Phillips, J. B., & Perdelwitz, J. R. (2007). Predicting dual-task performance with the Multiple Resources Questionnaire (MRQ). *Human Factors: The Journal of the Human Factors and Ergonomics Society, 49*(1), 32-45. doi:10.1518/001872007779598073

Bolia, R. S., Nelson, W. T., & Vidulich, M. A. (2004). A multi-layer visual display for air battle managers: Effects of depth and transparency on performance and workload in a dual-task scenario. *Human Factors and Aerospace Safety, 4*(3), 181-193.

Bolton, A. E. (2007). Immediate versus delayed feedback in simulation-based training: Matching feedback delivery timing to the cognitive demands of the training exercise (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3233644)

Borenstein, M., Hedges, L. V., Higgins, J., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods, 1*(2), 97-111. doi:10.1002/jrsm.12

Bosshardt, H. G. (2006). Cognitive processing load as a determinant of stuttering: Summary of a research programme. *Clinical Linguistics & Phonetics*, *20*(5), 371-385. doi:10.1080/02699200500074321

Braby, C. D., Harris, D., & Muir, H. C. (1993). A psychophysiological approach to the assessment of work underload. *Ergonomics, 36*(9), 1035-1042. doi:10.1080/00140139308967975

Bradford, G. R. (2011). A relationship study of student satisfaction with learning online and cognitive load: Initial results. *The Internet and Higher Education, 14*(4), 217-226. doi:10.1016/j.iheduc.2011.05.001

Brauer, S. G., Broome, A., Stone, C., Clewett, S., & Herzig, P. (2004). Simplest tasks have greatest dual task interference with balance in brain injured adults. *Human Movement Science, 23*(3), 489-502. doi:10.1016/j.humov.2004.08.020

Brünken, R., Plass, J. L., & Leutner, D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 53-61. doi:10.1207/S15326985EP3801_7

Brünken, R., Plass, J. L., & Leutner, D. (2004). Assessment of cognitive load in multimedia learning with dual-task methodology: Auditory load and modality effects. *Instructional Science, 32*(1-2), 115-132. doi:10.1023/B:TRUC.0000021812.96911.c5

Brünken, R., Steinbacher, S., Plass, J.L., & Leutner, D. (2002). Assessment of cognitive load in multimedia learning using dual-task methodology. *Experimental Psychology, 49*(2), 109-119. doi:10.1027/1618-3169.49.2.10

Brunyé, T. T., Taylor, H. A., Rapp, D. N., & Spiro, A. B. (2006). Learning procedures: The role of working memory in multimedia learning experiences. *Applied Cognitive Psychology, 20*(7), 917-940. doi:10.1002/acp.1236

Burkes, K. M. E. (2007). Applying cognitive load theory to the design of online learning (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3276428)

Burnham, B. R. (2010). Cognitive load modulates attentional capture by color singletons during effortful visual search. *Acta psychologica*, *135*(1), 50-58. doi:10.1016/j.actpsy.2010.05.003

Burnham, B. R., Sabia, M., & Langan, C. (2014). Components of working memory and visual selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, *40*(1), 391. doi:10.1037/a0033753

Cameron, G. L. (2012). Whole-task approaches: The effects of the simplifying conditions and emphasis manipulation approaches on instructional efficiency (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3505770)

Casali, J.G. & Wierwille, W.W. (1983). A comparison of rating scale, secondary-task, physiological, and primary-task workload estimation techniques in a simulated flight task emphasizing communications load. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 25*(6), 623-641. doi:10.1177/001872088302500602

Chaffin, C. R. (2009). An Examination of the Cognitive Workload Associated with Conducting in an Instrumental Music Context (Doctoral dissertation). ProQuest LLC.

Chan, J. L., & DeSouza, J. F. (2013). The effects of attentional load on saccadic task switching. *Experimental Brain Research, 227*(3), 301-309. doi:10.1007/s00221-013-3452-1

Chandler, P. (2004). The crucial role of cognitive processes in the design of dynamic visualizations. *Learning and Instruction, 14*(3), 353-357.

Chandler, P. & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, *8*(4), 293-332. doi:10.1207/s1532690xci0804_2

Chandler, P., & Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology*, *10*(2), 151-170. doi:10.1002/(SICI)1099-0720(199604)10:2<151::AID-ACP380>3.0.CO;2-U

Chang, C. C., Lei, H., & Tseng, J. S. (2011). Media presentation mode, English listening comprehension and cognitive load in ubiquitous learning environments: Modality effect or redundancy effect? *Australasian Journal of Educational Technology*, *27*(4), 633-654.

Chang, C. C., Tseng, K. H., & Tseng, J. S. (2011). Is single or dual channel with different English proficiencies better for English listening comprehension, cognitive load and attitude in ubiquitous learning environment? *Computers & Education*, *57*(4), 2313-2321. doi:10.1016/j.compedu.2011.06.006

Charleston, D. E., & Boyer, R. W. (1990). Variance as a measure of dual task interference. *Psychological Reports*, *67*(2), 606-606.

Chen, I. J., & Chang, C. C. (2009). Cognitive load theory: An empirical study of anxiety and task performance in language learning. *Electronic Journal of Research in Educational Psychology*, *7*(2), 729-746.

Chen, Y. (2014). Learning protein structure with peers in an AR-enhanced learning environment (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3588651)

Chen, M. P., Wang, L. C., Chen, H. J., & Chen, Y. C. (2014). Effects of type of multimedia strategy on learning of Chinese characters for non-native novices. *Computers & Education*, *70*, 41-52. doi:10.1016/j.compedu.2013.07.042

Cheon, J. (2009). The effects of metaphorical interface on germane cognitive load (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3328186)

Cheon, J. & Grant, M. (2012a). Examining the relationships of different cognitive load types related to user interface in web-based instruction. *Journal of Interactive Learning Research*, *23*(1), 29-55.

Cheon, J., & Grant, M. M. (2012b). The effects of metaphorical interface on germane cognitive load in web-based instruction. *Educational Technology Research and Development*, *60*(3), 399-420. doi:10.1007/s11423-012-9236-7

Cheung, O. S., & Gauthier, I. (2010). Selective interference on the holistic processing of faces in working memory. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(2), 448. doi: 10.1037/a0016471

Chi, C. F., Lin, Y. H., & Lan, W. S. (2003). Measurement of information processing load and visual load on a dynamic information processing task. *Behaviour & Information Technology*, *22*(5), 365-374. doi:10.1080/01449290310001593621

Cierniak, G., Scheiter, K., & Gerjets, P. (2009). Explaining the split-attention effect: Is the reduction of extraneous cognitive load accompanied by an increase in germane cognitive load? *Computers in Human Behavior*, *25*(2), 315-324. doi:10.1016/j.chb.2008.12.020

Clarke, T., Ayres, P., & Sweller, J. (2005). The impact of sequencing and prior knowledge on learning mathematics through spreadsheet applications. *Educational Technology Research and Development*, *53*(3), 15-24. doi:10.1007/BF02504794

Cook, A., Zheng, R. & Blaz, J. W. (2009). Measurement of cognitive load during multimedia learning activities. In R. Zheng (Ed.), Cognitive effectives of multimedia learning (pp. 34–50). Hershey, PA: Information Science Reference/IGI Global Publishing.

Cottam, M. E. (2010). The effects of visual and textual annotations on Spanish listening comprehension, vocabulary acquisition, and cognitive load (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3428323)

Damos, D. L., & Bloem, K. A. (1985). Type A behavior pattern, multiple-task performance, and subjective estimation of mental workload. *Bulletin of the Psychonomic Society*, *23*(1), 53-56. doi:10.3758/BF03329777

Dang, T. D., Chen, G. D., Dang, G., & Li, L. Y. (2013). RoLo: A dictionary interface that minimizes extraneous cognitive load of lookup and supports incidental and incremental learning of vocabulary. *Computers & Education, 61*, 251-260. doi:10.1016/j.compedu.2012.10.006

Danilenko, E. P. (2010). The relationship of scaffolding on cognitive load in an online self-regulated learning environment (Doctoral dissertation). Available from ERIC. (UMI No. 3433765)

Darabi, A., & Jin, L. (2013). Improving the quality of online discussion: The effects of strategies designed based on cognitive load theory principles. *Distance Education*, *34*(1), 21-36. doi:10.1080/01587919.2013.770429

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional Science, 38*(2), 105-134. doi:10.1007/s11251-009-9110-0

De Neys, W., & Schaeken, W. (2007). When people are more logical under cognitive load: Dual task impact on scalar implicature. *Experimental Psychology*, *54*(2), 128-133 doi:10.1027/1618-3169.54.2.128

De Rivecourt, M., Kuperus, M. N., Post, W. J., & Mulder, L. J. M. (2008). Cardiovascular and eye activity measures as indices for momentary changes in mental effort during simulated flight. *Ergonomics*, *51*(9), 1295-1319.

doi:10.1080/00140130802120267

De Zambotti, M., Covassin, N., Cellini, N., Sarlo, M., & Stegagno, L. (2012). Cardiac autonomic profile during rest and working memory load in essential hypotensive women. *International Journal of Psychophysiology, 85*(2), 200-205. doi:10.1016/j.ijpsycho.2012.05.002

Decker, S. L. (2010). Tactile measures in the structure of intelligence. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie expérimentale, 64*(1), 53-59. doi:10.1037/a0015845

DeHaan, J. W. (2008). Video games and second language acquisition: The effect of interactivity with a rhythm video game on second language vocabulary recall, cognitive load, and telepresence (Doctoral dissertation). New York University, US.

DeHaan, J., Reed, W. M., & Kuwada, K. (2010). The effect of interactivity with a music video game on second language vocabulary recall. *Language Learning & Technology, 14*(2), 74-94.

DeLeeuw, K.E. & Mayer, R.E. (2008). A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. *Journal of Educational Psychology, 100*(1), 223-234

Dey, A. K., & Mann, D. D. (2010). A complete task analysis to measure the workload associated with operating an agricultural sprayer equipped with a navigation device. *Applied Ergonomics, 41*(1), 146-149. doi:10.1016/j.apergo.2009.06.005

Di Giorgio, E., Turati, C., & Altoe, G. (2012). Face detection in complex visual displays: An eye-tracking study with 3- and 6-month-old infants and adults. *Journal of Experimental Child Psychology, 113*(1), 66-77.

Di Stasi, L. L., Marchitto, M., Antolí, A., Baccino, T., & Cañas, J. J. (2010). Approximation of on-line mental workload index in ATC simulated multitasks. *Journal of Air Transport Management, 16*(6), 330-333. doi:10.1016/j.jairtraman.2010.02.004

DiDomenico, A., & Nussbaum, M. A. (2008). Interactive effects of physical and mental workload on subjective workload assessment. *International Journal of Industrial Ergonomics, 38*(11), 977-983. doi:10.1016/j.ergon.2008.01.012

DiDomenico, A., & Nussbaum, M. A. (2011). Effects of different physical workload parameters on mental workload and performance. *International Journal of Industrial Ergonomics, 41*(3), 255-260. doi:10.1016/j.ergon.2011.01.008

Dionisio, D. P., Granholm, E., Hillix, W. A., & Perrine, W. F. (2001). Differentiation of deception using pupillary responses as an index of cognitive processing. *Psychophysiology, 38*(2), 205-211. doi:10.1111/1469-8986.3820205

Dockree, P. M., Bellgrove, M. A., O'Keeffe, F. M., Moloney, P., Aimola, L., Carton, S., & Robertson, I. H. (2006). Sustained attention in traumatic brain injury (tbi) and healthy controls: enhanced sensitivity with dual-task load. *Experimental Brain Research, 168*(1-2), 218-229 . doi:10.1007/s00221-005-0079-x

Dodds, C. M., van Belle, J., Peers, P. V., Dove, A., Cusack, R., Duncan, J., & Manly, T. (2008). The effects of time-on-task and concurrent cognitive load on normal visuospatial bias. *Neuropsychology, 22*(4), 545-552. doi:10.1037/0894-4105.22.4.545

Doering, A., & Veletsianos, G. (2007). Multi-scaffolding environment: An analysis of scaffolding and its impact on cognitive load and problem-solving ability. *Journal of Educational Computing Research, 37*(2), 107-129. doi:10.2190/Q58T-4388-8015-8141

Doherty-Sneddon, G., Bonner, L., & Bruce, V. (2001). Cognitive demands of face monitoring: Evidence for visuospatial overload. *Memory & Cognition, 29*(7), 909-919. doi:10.3758/BF03195753

Doherty-Sneddon, G., Riby, D. M., & Whittle, L. (2012). Gaze aversion as a cognitive load management strategy in autism spectrum disorder and Williams syndrome. *Journal of Child Psychology and Psychiatry, 53*(4), 420-430. doi:10.1111/j.1469-7610.2011.02481.x

Doolittle, P.E (1995). Understanding cooperative learning through Vygotsky's zone of proximal development. Speech presented at *Lilly National Conference on Excellence in College Teaching*, Columbia, SC.

Dotsoev, L. Y., Usynin, A. M., Vagner, N. I., & Tutatchikov, A. T. (2003). Functional state of 11-to 12-year-old schoolchildren under conditions of intense academic load assessed by heart rate variability. *Human Physiology, 29*(4), 444-447. doi:10.1023/A:1024977406829

Doumas, M., Rapp, M. A., & Krampe, R. T. (2009). Working memory and postural control: Adult age differences in potential for improvement, task priority, and dual tasking. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 64B*(2), 193–201. doi:10.1093/geronb/gbp00

Doyle, M., & Furnham, A. (2012). The distracting effects of music on the cognitive test performance of creative and non-creative individuals. *Thinking Skills and Creativity, 7*(1), 1-7. doi:10.1016/j.tsc.2011.09.002

Durantin, G., Gagnon, J. F., Tremblay, S., & Dehais, F. (2014). Using near infrared spectroscopy and heart rate variability to detect mental overload. *Behavioural Brain Research, 259*, 16-23. doi:10.1016/j.bbr.2013.10.042

Dutke, S., Jaitner, T., Berse, T., & Barenberg, J. (2014). Acute physical exercise affected processing efficiency in an auditory attention task more than processing effectiveness. *Journal of Sport & Exercise Psychology, 36*(1), 69-79. doi:10.1123/jsep.2013-0044

Duval, S., & Tweedie, R. (2000). Trim and fill: a simple funnel-plot–based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*(2), 455-463.

Engström, J., Johansson, E., & Östlund, J. (2005). Effects of visual and cognitive load in real and simulated motorway driving. *Transportation Research Part F, 8*, 97-120.

Erlandson, B. E., Nelson, B. C., & Savenye, W. C. (2010). Collaboration modality, cognitive load, and science inquiry learning in virtual inquiry environments. *Educational Technology Research and Development, 58*(6), 693-710. doi:10.1007/s11423-010-9152-7

Evans, D. E., Craig, C., Oliver, J. A., & Drobes, D. J. (2010). The smoking N-back: a measure of biased cue processing at varying levels of cognitive load. *Nicotine & Tobacco Research, 13*(2), 88-93. doi:10.1093/ntr/ntq214

Eveland, W. P., & Dunwoody, S. (2001). User control and structural isomorphism or disorientation and cognitive load? Learning from the Web versus print. *Communication Research, 28*(1), 48-78. doi:10.1177/009365001028001002

Farnsworth, C. J. (2010). The cognitive load impacts of assistive technology devices used by sighted teachers in training during literary braille instruction (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3404507)

Feil, A. J. (2009) Attention and encoding in physics learning and problem solving (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3392010)

Field, A. P., & Gillett, R. (2010). How to do a meta-analysis. *British Journal of Mathematical and Statistical Psychology, 63*(3), 665-694. doi: 10.1348/000711010X502733

Field, M., Mogg, K., & Bradley, B. P. (2006). Automaticity of smoking behaviour: The relationship between dual-task performance, daily cigarette intake and subjective nicotine effects. *Journal of Psychopharmacology, 20*(6), 799-805. doi:10.1177/0269881106063997

Fischer, M. H., Riello, M., Giordano, B. L., & Rusconi, E. (2013). Singing numbers… in cognitive space—A dual-task study of the link between pitch, space, and numbers. *Topics in Cognitive Science, 5*(2), 354-366. doi:10.1111/tops.12017

Fishel, S. R., Muth, E. R., & Hoover, A. W. (2007). Establishing appropriate physiological baseline procedures for real-time physiological measurement.

Journal of Cognitive Engineering and Decision Making, 1(3), 286-308. doi:10.1518/155534307X255636

Fitousi, D., & Wenger, M. J. (2011). Processing capacity under perceptual and cognitive load: A closer look at load theory. *Journal of Experimental Psychology: Human Perception and Performance, 37*(3), 781-798. doi: 10.1037/a0020675

Flad, J. A. (2002). The effects of increasing cognitive load on self-report and dual-task measures of mental effort during problem solving (Doctoral dissertation. Available from ProQuest. Dissertations and Theses database. (UMI No. 3093760)

Fleiss, J. L., & Gross, A. J. (1991). Meta-analysis in epidemiology, with special reference to studies of the association between exposure to environmental tobacco smoke and lung cancer: a critique. *Journal of Clinical Epidemiology, 44*(2), 127-139.

Foor, J. L. (2011). The effectiveness of an online knowledge map instructional presentation (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3471708)

Frank, S. L. (2013). Uncertainty reduction as a measure of cognitive load in sentence comprehension. *Topics in Cognitive Science, 5*(3), 475-494. doi:10.1111/tops.12025

Franz, M., Schaefer, R., & Schneider, C. (2003). Psychophysiological response patterns of high and low alexithymics under mental and emotional load conditions. *Journal of Psychophysiology, 17*(4), 203-213. doi:10.1027/0269-8803.17.4.203

Fraser, K., Ma, I., Teteris, E., Baxter, H., Wright, B., & McLaughlin, K. (2012). Emotion, cognitive load and learning outcomes during simulation training. *Medical Education, 46*(11), 1055-1062. doi:10.1111/j.1365-2923.2012.04355.x

Fraser, S. A., Li, K. Z., & Penhune, V. B. (2010). Dual-task performance reveals increased involvement of executive control in fine motor sequencing in healthy aging. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 65*(5), 526-535. doi:10.1093/geronb/gbq036

Fredericks, T. K., Choi, S. D., Hart, J., Butt, S. E., & Mital, A. (2005). An investigation of myocardial aerobic capacity as a measure of both physical and cognitive workloads. *International Journal of Industrial Ergonomics, 35*(12), 1097-1107. doi:10.1016/j.ergon.2005.06.002

Friend, K. E. (1982). Stress and Performance: Effects of subjective work load and time urgency. *Personnel Psychology, 35*(3), 623-633. doi:10.1111/j.1744-6570.1982.tb02214.x

Funke, G. J., & Galster, S. M. (2009). The effects of cognitive processing load and collaboration technology on team performance in a simulated command and control environment. *International Journal of Industrial Ergonomics, 39*(3), 541-

547. doi:10.1016/j.ergon.2008.10.007

Galy, E., Cariou, M., & Mélan, C. (2012). What is the relationship between mental workload factors and cognitive load types? *International Journal of Psychophysiology, 83*(3), 269-275. doi:10.1016/j.ijpsycho.2011.09.023

Gerjets, P., Scheiter, K., & Catrambone, R. (2004). Designing instructional examples to reduce intrinsic cognitive load: Molar versus modular presentation of solution procedures. *Instructional Science, 32*(1-2), 33-58. doi:10.1023/B:TRUC.0000021809.10236.71

Granholm, E., & Steinhauer, S. R. (2004). Pupillometric measures of cognitive and emotional processes. *International Journal of Psychophysiology, 52*(1), 1-6.

Granier, J. P., Robin, D. A., Shapiro, L. P., Peach, R. K., & Zimba, L. D. (2000). Measuring processing load during sentence comprehension: Visuomotor tracking. *Aphasiology, 14*(5-6), 501-513. doi:10.1080/026870300401270

Grimley, M. (2007). Learning from multimedia materials: The relative impact of individual differences. *Educational Psychology, 27*(4), 465-485. doi:10.1080/01443410601159795

Guttormsen Schär, S., & Zimmermann, P. G. (2007). Investigating means to reduce cognitive load from animations: Applying differentiated measures of knowledge representation. *Journal of Research on Technology in Education, 40*(1), 64-78. doi:10.1080/15391523.2007.10782497

Halford, G. S., Maybery, M. T., & Bain, J. D. (1986). Capacity limitations in children's reasoning: A dual-task approach. *Child Development, 57*(3), 616-627.

Hancock, P. A. (1996). Effects of control order, augmented feedback, input device and practice on tracking performance and perceived workload. *Ergonomics, 39*(9), 1146-1162. doi:10.1080/00140139608964535

Harper, S., Michailidou, E., & Stevens, R. (2009). Toward a definition of visual complexity as an implicit measure of cognitive load. *ACM Transactions on Applied Perception (TAP), 6*(2), 10:1-18. doi:10.1145/1498700.1498704

Haslam, C. Y., & Hamilton, R. J. (2010). Investigating the use of integrated instructions to reduce the cognitive load associated with doing practical work in secondary school science. *International Journal of Science Education, 32*(13), 1715-1737. doi:10.1080/09500690903183741

Hasler, B. S., Kersten, B., & Sweller, J. (2007). Learner control, cognitive load and instructional animation. *Applied Cognitive Psychology, 21*(6), 713-729. doi:10.1002/acp.1345

Hawkins, K. M., Perry, C. J., Kiriella, J. B., Shanahan, C. J., Moore, A. E., & Gage, W.

H. (2010). Attentional demands associated with obstacle crossing while carrying a load. *Journal of Motor Behavior*, *43*(1), 37-44. doi:10.1080/00222895.2010.530307

Hogg, N. M. (2004). Designing instructional materials for teaching HTML to create web page tables: Applying cognitive load theory (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3126953)

Hollender, N., Hofmann, C., Deneke, M., & Schmitz, B. (2010). Integrating cognitive load theory and concepts of human–computer interaction. *Computers in Human Behavior, 26*(6), 1278-1288. doi:10.1016/j.chb.2010.05.031

Homer, B. D., Plass, J. L., & Blake, L. (2008). The effects of video on cognitive load and social presence in multimedia-learning. *Computers in Human Behavior*, *24*(3), 786-797. doi:10.1016/j.chb.2007.02.009

Hoover, A., Singh, A., Fishel-Brown, S., & Muth, E. (2012). Real-time detection of workload changes using heart rate variability. *Biomedical Signal Processing and Control*, *7*(4), 333-341. doi:10.1016/j.bspc.2011.07.004

Hsiao, A., Brouns, F., Van Bruggen, J., & Sloep, P. (2012). Effects of peer-tutor competences on learner cognitive load and learning performance during knowledge sharing. Paper presented at the *International Association for Development of the Information Society (IADIS) International Conference on Cognition and Exploratory Learning in Digital Age*, Madrid, Spain.

Hwang, M. Y., Hong, J. C., Cheng, H. Y., Peng, Y. C., & Wu, N. C. (2013). Gender differences in cognitive load and competition anxiety affect 6th grade students' attitude toward playing and intention to play at a sequential or synchronous game. *Computers & Education*, *60*(1), 254-263. doi:10.1016/j.compedu.2012.06.014

Hwang, G. J., Kuo, F. R., Chen, N. S., & Ho, H. J. (2014). Effects of an integrated concept mapping and web-based problem-solving approach on students' learning achievements, perceptions and cognitive loads. *Computers & Education*, *71*, 77-86. doi:10.1016/j.compedu.2013.09.013

Hyönä, J., Tommola, J., & Alaja, A. M. (1995). Pupil dilation as a measure of processing load in simultaneous interpretation and other language tasks. *The Quarterly Journal of Experimental Psychology*, *48*(3), 598-612. doi:10.1080/14640749508401407

Iani, C., Gopher, D., Grunwald, A. J., & Lavie, P. (2007). Peripheral arterial tone as an on-line measure of load in a simulated flight task. *Ergonomics, 50*(7), 1026-1035. doi:10.1080/00140130701303386

Impelluso, T. J. (2009). Assessing cognitive load theory to improve student learning for mechanical engineers. *The American Journal of Distance Education, 23*(4), 179-193. doi:10.1080/08923640903294569

Itoh, Y., Hayashi, Y., Tsukui, I., & Saito, S. (1990). The ergonomic evaluation of eye movement and mental workload in aircraft pilots. *Ergonomics, 33*(6), 719-732. doi:10.1080/00140139008927181

Jaeggi, S. M., Schmid, C., Buschkuehl, M., & Perrig, W. J. (2008). Differential age effects in load-dependent memory processing. *Aging, Neuropsychology, and Cognition, 16*(1), 80-102. doi:10.1080/13825580802233426

Jameson, A., Kiefer, J., Müller, C., Großmann-Hutter, B., Wittig, F., & Rummer, R. (2009). Assessment of a user's time pressure and cognitive load on the basis of features of speech. In M. W. Crocker and J. Siekmann (Eds.), *Resource-Adaptive Cognitive Processes* (pp. 171-204). Berlin, Germany: Springer.

Jameson, T. L. (2004). Working memory and individual differences in decision making (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3162111)

Jin, L. (2013). Example postings' effects on online discussion and cognitive load (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3551240)

Johansson, R., Holmqvist, K., Mossberg, F., & Lindgren, M. (2012). Eye movements and reading comprehension while listening to preferred and non-preferred study music. *Psychology of Music, 40*(3), 339-356. doi: 10.1177/0305735610387777

Johnson, A. M. (2012). Integration scaffolding in hypermedia learning (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3476365)

Johnson, D. L. (2007). Rapid dynamic assessment of expertise: A comparison of performance and mental efficiency measures in accordance with cognitive load theory (Doctoral thesis). Available from ProQuest Dissertations and Theses database. (UMI No. 3289155)

Johnson, J. S., Liu, L., Thomas, G., & Spencer, J. P. (2007). Calibration algorithm for eyetracking with unrestricted head movement. *Behavior Research Methods, 39*(1), 123-132. doi:10.3758/BF03192850

Johnston, J. H., Fiore, S. M., Paris, C., & Smith, C. A. P. (2013). Application of cognitive load theory to develop a measure of team cognitive efficiency. *Military Psychology, 25*(3), 252. doi:10.1037/h0094967

Jones, R. M., Fox, R. A., & Jacewicz, E. (2012). The effects of concurrent cognitive load on phonological processing in adults who stutter. *Journal of Speech, Language, and Hearing Research, 55*(6), 1862-1875. doi:10.1044/1092-4388(2012/12-0014)

Jorna, P. G. A. M. (1993). Heart rate and workload variations in actual and simulated flight. *Ergonomics, 36*(9), 1043-1054. doi:10.1080/00140139308967976

Joseph, S. (2014). Measuring cognitive load: A comparison of self-report and physiological methods (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3560171)

Kaiser, J., Beauvale, A., & Bener, J. (1997). The evoked cardiac response as a function of cognitive load differs between subjects separated on the main personality dimensions. *Personality and Individual Differences, 22*(2), 241-248. doi:10.1016/S0191-8869(96)00188-2

Kalyuga, S. (2009). Instructional designs for the development of transferable knowledge and skills: A cognitive load perspective. *Computers in Human Behavior, 25*(2), 332-338. doi:10.1016/j.chb.2008.12.019

Kalyuga, S., Chandler, P., & Sweller, J. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology, 13*(4), 351-371.

Kalyuga, S., Chandler, P., & Sweller, J. (2000). Incorporating learner experience into the design of multimedia instruction. *Journal of Educational Psychology, 92*(1), 126-136. doi:10.1037/0022-0663.92.1.126

Kalyuga, S., & Sweller, J. (2004). Measuring knowledge to optimize cognitive load factors during instruction. *Journal of Educational Psychology, 96*(3), 558. doi:10.1037/0022-0663.96.3.558

Kalyuga, S., & Sweller, J. (2005). Rapid dynamic assessment of expertise to improve the efficiency of adaptive e-learning. *Educational Technology Research and Development, 53*(3), 83-93. doi:10.1007/BF02504800

Kantner, J. (2009). Studying with music: Is the irrelevant speech effect relevant? In M. R. Kelley (Ed.), *Applied Memory,* (pp. 19-40). Hauppauge, NY, US: Nova Science Publishers.

Kester, L., Kirschner, P. A., & Merriënboer, J. J. (2005). The management of cognitive load during complex cognitive skill acquisition by means of computer-simulated problem solving. *British Journal of Educational Psychology, 75*(1), 71-85. doi:10.1348/000709904X19254

Ketelsen, K., & Welsh, M. (2010). Working memory and mental arithmetic: A case for dual central executive resources. *Brain and Cognition, 74*(3), 203-209. doi:10.1016/j.bandc.2010.07.011

Khawaja, M. A., Chen, F., & Marcus, N. (2012). Analysis of collaborative communication for linguistic cues of cognitive load. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 54*(4), 518-529. doi: 10.1177/0018720811431258

Khawaja, M. A., Chen, F., & Marcus, N. (2014). Measuring cognitive load using linguistic features: Implications for usability evaluation and adaptive interaction design. *International Journal of Human-Computer Interaction, 30*(5), 343-368. doi:10.1080/10447318.2013.860579

Klatzky, R. L., Marston, J. R., Giudice, N. A., Golledge, R. G., & Loomis, J. M. (2006). Cognitive load of navigating without vision when guided by virtual sound versus spatial language. *Journal of Experimental Psychology: Applied, 12*(4), 223-232. doi:10.1037/1076-898X.12.4.223

Klemen, J., Büchel, C., Bühler, M., Menz, M. M., & Rose, M. (2010). Auditory working memory load impairs visual ventral stream processing: Toward a unified model of attentional load. *Journal of Cognitive Neuroscience, 22*(3), 437-446. doi:10.1162/jocn.2009.21204

Kline, P. (2000). The handbook of psychological testing (2nd ed.). New York, NY: Routledge.

Klingner, J., Tversky, B., & Hanrahan, P. (2011). Effects of visual and verbal presentation on cognitive load in vigilance, memory, and arithmetic tasks. *Psychophysiology, 48*(3), 323-332. doi:10.1111/j.1469-8986.2010.01069.x

Knowlton, S. W., & Berger, C. R. (1997). Message planning, communication failure, and cognitive load. *Human Communication Research, 24*(1), 4-30. doi:10.1111/j.1468-2958.1997.tb00585.x

Kobayashi, K., & Yamada, S. (2010). Extending commands embedded in actions for human-robot cooperative tasks. *International Journal of Social Robotics, 2*(2), 159-173. doi:10.1007/s12369-010-0054-y

Krans, J., Langner, O., Reinecke, A., & Pearson, D. G. (2013). Intrusive images and voluntary memory for affective pictures: Contextualization and dual-task interference. *Journal of Behavior Therapy and Experimental Psychiatry, 44*(4), 418-425. doi:10.1016/j.jbtep.2013.05.001

Kroneisen, M., Rummel, J., & Erdfelder, E. (2014). Working memory load eliminates the survival processing effect. *Memory, 22*(1), 92-102. doi:10.1080/09658211.2013.815217

Krüger, F., Nuthmann, A., & Van Der Meer, E. (2001). Pupillometric indices of temporal order representation in semantic memory. *Zeitschrift für Psychologie, 209*(4), 402-415.doi:10.1026//0044-3409.209.4.402

Kühl, T., Scheiter, K., Gerjets, P., & Edelmann, J. (2011). The influence of text modality on learning with static and dynamic visualizations. *Computers in Human Behavior, 27*(1), 29-35. doi:10.1016/j.chb.2010.05.008

Kumar, M., (2006). Reducing the cost of eye tracking systems. *GUIDe: Gaze-enhanced User Interface Design*, *Stanford*. Retrieved from http://hci.stanford.edu/cstr/reports/2006-08.pdf

Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A hybrid approach to promoting students' web-based problem-solving competence and learning attitude. *Computers & Education, 58*(1), 351-364. doi:10.1016/j.compedu.2011.09.020

Lachmann, T., & Van Leeuwen, C. (2007). Goodness takes effort: Perceptual organization in dual-task settings. *Psychological Research, 71*(2), 152-169. doi:10.1007/s00426-005-0001-y

Lahtinen, T. M., Koskelo, J. P., Laitinen, T., & Leino, T. K. (2007). Heart rate and performance during combat missions in a flight simulator. *Aviation, Space, and Environmental Medicine, 78*(4), 387-391.

Lambert, J., Kalyuga, S., & Capan, L. A. (2009). Student perceptions and cognitive load: What can they tell us about e-learning Web 2.0 course design. *E–Learning, 6*(2), 150-163. doi:10.2304/elea.2009.6.2.150

Lamberts, K., & d'Ydewalle, G. (1990). Hemisphere-specific resource demands of task expectancies. *The Quarterly Journal of Experimental Psychology, 42*(1), 87-104. doi:10.1080/14640749008401209

Lan, T., Erdogmus, D., Adami, A., Mathan, S., & Pavel, M. (2007). Channel selection and feature projection for cognitive load estimation using ambulatory EEG. *Computational Intelligence and Neuroscience, 2007,* 1-12. doi:10.1155/2007/74895

Lane, D.M. (2015). Unequal sample sizes. Retrieved on July 16, 2015 from http://onlinestatbook.com/2/analysis_of_variance/unequal.html.

Lang, A., Kurita, S., Gao, Y., & Rubenking, B. (2013). Measuring television message complexity as available processing resources: Dimensions of information and cognitive load. *Media Psychology, 16*(2), 129-153. doi: 10.1080/15213269.2013.764707

Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General, 133*(3), 339. doi:10.1037/0096-3445.133.3.339

Lavie, N., & Torralbo, A. (2010). Dilution: A theoretical burden or just load? A reply to Tsal and Benoni (2010). *Journal of Experimental Psychology: Human Perception and Performance, 36*(6), 1657-1664. doi:10.1037/a0020733

Lawrence, C. A., & Barry, R. J. (2009). ERPs and the evoked cardiac response to auditory stimuli: Intensity and cognitive load effects. *Acta Neurobiologiae Experimentalis, 69*(4), 552-559.

Le, P. N., Ambikairajah, E., Epps, J., Sethu, V., & Choi, E. H. (2011). Investigation of spectral centroid features for cognitive load classification. *Speech Communication, 53*(4), 540-551. doi:10.1016/j.specom.2011.01.005

Leahy, W., & Sweller, J. (2008). The imagination effect increases with an increased intrinsic cognitive load. *Applied Cognitive Psychology, 22*(2), 273-283. doi:10.1002/acp.1373

Lee, C. H., & Kalyuga, S. (2011). Effectiveness of different pinyin presentation formats in learning Chinese characters: A cognitive load perspective. *Language Learning, 61*(4), 1099-1118. doi:10.1111/j.1467-9922.2011.00666.x

Lee, H., Plass, J. L., & Homer, B. D. (2006). Optimizing cognitive load for learning from computer-based science simulations. *Journal of Educational Psychology, 98*(4), 902. doi:10.1037/0022-0663.98.4.902

Lehrer, P., Karavidas, M., Lu, S. E., Vaschillo, E., Vaschillo, B., & Cheng, A. (2010). Cardiac data increase association between self-report and both expert ratings of task load and task performance in flight simulator tasks: An exploratory study. *International Journal of Psychophysiology, 76*(2), 80-87. doi:10.1016/j.ijpsycho.2010.02.006

Lejbak, L., Crossley, M., & Vrbancic, M. (2011). A male advantage for spatial and object but not verbal working memory using the n-back task. *Brain and Cognition, 76*(1), 191-196. doi:10.1016/j.bandc.2010.12.002

Leppink, J., Paas, F., Van der Vleuten, C.P., Van Gog, T., & Van Merriënboer, J.J., (2013). Development of an instrument for measuring different types of cognitive load. *Behavior Research Methods, 45,* 1058-1072. doi: 10.3758/s13428-013-0334-1

Leppink, J., Paas, F., Van Gog, T., van Der Vleuten, C. P., & Van Merriënboer, J. J. (2014). Effects of pairs of problems and examples on task performance and different types of cognitive load. *Learning and Instruction, 30*, 32-42. doi:10.1016/j.learninstruc.2013.12.001

Leutner, D., Leopold, C., & Sumfleth, E. (2009). Cognitive load and science text comprehension: Effects of drawing and mentally imagining text content. *Computers in Human Behavior, 25*(2), 284-289. doi:10.1016/j.chb.2008.12.010

Leyman, E. L., Mirka, G. A., Kaber, D. B., & Sommerich, C. M. (2004). Cervicobrachial muscle response to cognitive load in a dual-task scenario. *Ergonomics, 47*(6), 625-645. doi:10.1080/00140130310001629766

Lin, H., & Chen, T. (2006). Decreasing cognitive load for novice EFL learners: Effects of question and descriptive advance organizers in facilitating EFL learners' comprehension of an animation-based content lesson. *System, 34*(3), 416-431. doi:10.1016/j.system.2006.04.008

Lin, T., Xie, T., Chen, Y., & Tang, N. (2013). Automatic cognitive load evaluation using writing features: An exploratory study. *International Journal of Industrial Ergonomics, 43*(3), 210-217. doi:10.1016/j.ergon.2013.02.002

Lin, Y., Zhang, W. J., & Watson, L. G. (2003). Using eye movement parameters for evaluating human–machine interface frameworks under normal control operation and fault detection situations. *International Journal of Human-Computer Studies, 59*(6), 837-873. doi:10.1016/S1071-5819(03)00122-8

Lindholm, E., & Cheatham, C. M. (1983). Autonomic activity and workload during learning of a simulated aircraft carrier landing task. *Aviation, Space, and Environmental Medicine, 54*(5), 435-439.

Lipsey, M. W., & Williams, D. B. (2001). Practical meta-analysis. L. Bickman, & D. J. Rog (Eds.). Thousand Oaks, CA: SAGE publications.

Liu, H. C., & Su, I. (2011). Learning residential electrical wiring through computer simulation: The impact of computer-based learning environments on student achievement and cognitive load. *British Journal of Educational Technology, 42*(4), 598-607. doi:10.1111/j.1467-8535.2009.01047.x

Loncke, M., Desmet, T., Vandierendonck, A., & Hartsuiker, R. J. (2011). Executive control is shared between sentence processing and digit maintenance: Evidence from a strictly timed dual-task paradigm. *Journal of Cognitive Psychology, 23*(7), 886-911. doi:10.1080/20445911.2011.586625

Lövdén, M., Schaefer, S., Pohlmeyer, A. E., & Lindenberger, U. (2008). Walking variability and working-memory load in aging: A dual-process account relating cognitive control to motor control performance. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 63*(3), P121-P128.

Lyons, L. C., & Morris, W. A. (n.d.). *The meta analysis calculator.* Retrieved from http://www.lyonsmorris.com/ma1/index.cfm

Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding instructions. *Journal of Educational Psychology, 88*(1), 49-63. doi:10.1037/0022-0663.88.1.49

Martin, S. (2012). Does instructional format really matter? Cognitive load theory, multimedia and teaching English Literature. *Educational Research and Evaluation, 18*(2), 125-152. doi:10.1080/13803611.2012.659899

Martin-Michiellot, S., & Mendelsohn, P. (2000). Cognitive load while learning with a graphical computer interface. *Journal of Computer Assisted Learning, 16*(4), 284-293. doi:10.1046/j.1365-2729.2000.00141.x

Matthews, G., Middleton, W., Gilmartin, B., & Bullimore, M. A. (1991). Pupillary diameter and cognitive load. *Journal of Psychophysiology, 5*(3), 265-271.

Mattis, K. V. (2013). The comparative effects of visual-only instruction versus modality principle instruction on algebraic problem accuracy and perceived mental effort at varying levels of task complexity for undergraduate nursing students (Doctoral dissertation). Available from PsycINFO database. (UMI No. 3526455)

Mattys, S. L., & Wiget, L. (2011). Effects of cognitive load on speech recognition. *Journal of Memory and Language, 65*(2), 145-160. doi:10.1016/j.jml.2011.04.004

May. P (2004). Analysis of computer algebra system tutorials using cognitive load theory. *The International Journal for Technology in Mathematics Education, 11*(4), 117-138.

Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction, 13*(2), 125-139. doi:10.1016/S0959-4752(02)00016-6

Mayer, R. E. (2012). Information processing. In K. R. Harris, S. Graham, T. Urdan, C. B. McCormick, G. M. Sinatra, J. Sweller (Eds.), *APA educational psychology handbook, Vol 1: Theories, constructs, and critical issues* (pp. 85-99). Washington, DC, US: American Psychological Association. doi:10.1037/13273-004

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology, 93*(2), 390-397. doi:10.1037/0022-0663.93.2.390

Mayer, R. E., & Johnson, C. I. (2008). Revising the redundancy principle in multimedia learning. *Journal of Educational Psychology, 100*(2), 380-386. doi:10.1037/0022-0663.100.2.380

Mayer, R. E., Lee, H., & Peebles, A. (2014). Multimedia learning in a second language: A cognitive load perspective. *Applied Cognitive Psychology, 28*(5), 653-660. doi:10.1002/acp.3050

Mayer, R. E., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction, 12*(1), 107-119. doi:10.1016/S0959-4752(01)00018-4

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology, 86*(3), 389-401. doi:10.1037/0022-0663.86.3.389

McIntosh, R. D., Mulroue, A., & Brockmole, J. R. (2010). How automatic is the hand's automatic pilot? *Experimental Brain Research, 206*(3), 257-269. doi:10.1007/s00221-010-2404-2

McVee, M.B., Dunsmore, K., & Gavelek, J.R. (2005) Schema theory revisited. *Review of Educational Research, 75*(4), 531-566. doi:10.3102/00346543075004531

Meissner, B., & Bogner, F. X. (2012). Science teaching based on cognitive load theory: Engaged students, but cognitive deficiencies. *Studies in Educational Evaluation, 38*(3), 127-134. doi:10.1016/j.stueduc.2012.10.002

Melzer, I., Liebermann, D. G., Krasovsky, T., & Oddsson, L. I. (2009). Cognitive load affects lower limb force–time relations during voluntary rapid stepping in healthy old and young adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 65A*(4), 400-406. doi:10.1093/gerona/glp185

Miller, C. (2011). Aesthetics and e-assessment: the interplay of emotional design and learner performance. *Distance Education, 32*(3), 307-337. doi:10.1080/01587919.2011.610291

Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81-97. Retrieved from http://homepage.psy.utexas.edu/HomePage/Class/Psy355/Gilden/MagicNumberSeven.pdf

Mitra, S., Knight, A., & Munn, A. (2013). Divergent effects of cognitive load on quiet stance and task-linked postural coordination. *Journal of experimental psychology: human perception and performance, 39*(2), 323. doi:10.1037/a0030588

Miyake, S. (2001). Multivariate workload evaluation combining physiological and subjective measures. *International Journal of Psychophysiology, 40*, 233-238. doi:10.1016/S0167-8760(00)00191-4

Mochizuki, H., Tashiro, M., Gyoba, J., Suzuki, M., Okamura, N., Itoh, M., & Yanai, K. (2007). Brain activity associated with dual-task management differs depending on the combinations of response modalities. *Brain Research, 1172*, 82-92. doi:10.1016/j.brainres.2007.07.046

Moos, D. (2013). Examining hypermedia learning: The role of cognitive load and self-regulated learning. *Journal of Educational Multimedia and Hypermedia, 22*(1), 39-61.

Morady, K., & Humphreys, G. W. (2009). Comparing action disorganization syndrome and dual-task load on normal performance in everyday action tasks. *Neurocase, 15*(1), 1-12. doi:10.1080/13554790802524214

Moreno, R. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback in discovery-based multimedia. *Instructional Science, 32*(1-2), 99-113. doi:10.1023/B:TRUC.0000021811.66966.1d

Moreno, R. (2007). Optimising learning from animations by minimising cognitive load: Cognitive and affective consequences of signalling and segmentation methods. *Applied Cognitive Psychology, 21*(6), 765-781. doi:10.1002/acp.1348

Moreno, R., & Valdez, A. (2005). Cognitive load and learning effects of having students organize pictures and words in multimedia environments: The role of student interactivity and feedback. *Educational Technology Research and Development, 53*(3), 35-45. doi:10.1007/BF02504796

Moresi, S., Adam, J. J., Rijcken, J., Van Gerven, P. W., Kuipers, H., & Jolles, J. (2008). Pupil dilation in response preparation. *International Journal of Psychophysiology, 67*(2), 124-130. doi:10.1016/j.ijpsycho.2007.10.011

Morozov, A. (2009). The effects of spatial visualization ability and graphical navigational aids on cognitive load and learning from web-based instruction. *Journal of Educational Multimedia and Hypermedia, 18*(1), 27-70.

Morrison, G. R., & Anglin, G. J. (2005). Research on cognitive load theory: Application to e-learning. *Educational Technology Research and Development, 53*(3), 94-104. doi:10.1007/BF02504801

Mousavi, S. Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology, 87*(2), 319-334. doi:10.1037/0022-0663.87.2.319

Moussa-Inaty, J., & Atallah, F. (2012). Multimedia use in higher education in the UAE: A cognitive load theory perspective. *Journal of Educational Multimedia and Hypermedia, 21*(2), 127-142.

Mulder, G., & Mulder, L. J. (1981). Information processing and cardiovascular control. *Psychophysiology, 18*(4), 392-402. doi:10.1111/j.1469-8986.1981.tb02470.x

Müller, A., Petru, R., & Angerer, P. (2011). Cognitive demands and the relationship between age and workload in apron control. *Aviation, Space, and Environmental Medicine, 82*(1), 26-33. doi:10.3357/ASEM.2797.2011

Muller, D. A., Sharma, M. D., & Reimann, P. (2008). Raising cognitive load with linear multimedia to promote conceptual change. *Science Education, 92*(2), 278-296. doi:10.1002/sce.20244

Muth, E. R., Moss, J. D., Rosopa, P. J., Salley, J. N., & Walker, A. D. (2012). Respiratory sinus arrhythmia as a measure of cognitive workload. *International Journal of Psychophysiology, 83*(1), 96-101. doi:10.1016/j.ijpsycho.2011.10.011

Myrtek, M., Deutschmann-Janicke, E., Strohmaier, H., Zimmermann, W., Lawerenz, S., Brügner, G., & Müller, W. (1994). Physical, mental, emotional, and subjective workload components in train drivers. *Ergonomics, 37*(7), 1195-1203. doi:10.1080/00140139408964897

Nagamatsu, L. S., Voss, M., Neider, M. B., Gaspar, J. G., Handy, T. C., Kramer, A. F., & Liu-Ambrose, T. Y. (2011). Increased cognitive load leads to impaired mobility decisions in seniors at risk for falls. *Psychology and Aging*, *26*(2), 253. doi:10.1037/a0022929

Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, *23*(3), 237-256. doi:10.2190/81BG-RPDJ-9FA0-Q7PA

Ohira, H. (1996). Eyeblink activity in a word-naming task as a function of semantic priming and cognitive load. *Perceptual and Motor Skills, 82*(3), 835-842. doi:10.2466/pms.1996.82.3.835

Ohsugi, H., Ohgi, S., Shigemori, K., & Schneider, E. B. (2013). Differences in dual-task performance and prefrontal cortex activation between younger and older adults. *BMC Neuroscience, 14*(1), 10. doi:10.1186/1471-2202-14-10

Owens, P., & Sweller, J. (2008). Cognitive load theory and music instruction. *Educational Psychology*, *28*(1), 29-45. doi:10.1080/01443410701369146

Paas, F. (1992) Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*(4), 429-434. doi:10.1037/0022-0663.84.4.429

Paas, F. & van Merriënboer, J. J. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 35*(4), 737-743. doi:10.1177/001872089303500412

Paas, F. & van Merriënboer, J. J. (1994). Instructional control of cognitive load in the training of complex cognitive tasks. *Educational Psychology Review*, *6*(4), 351-371. doi:10.1007/BF02213420

Paas, F. G., & Van Merriënboer, J. J. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology*, *86*(1), 122. doi:10.1037/0022-0663.86.1.122

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science, 32*(1-2), 1-8. doi:10.1023/B:TRUC.0000021806.17516.d0

Paas, F., Tuovinen, J.E., Tabbers, H., & Van Gerven, P.W. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, *38*(1), 63-71. doi:10.1207/S15326985EP3801_8

Paas, F., Tuovinen, J. E., Van Merriënboer, J. J., & Darabi, A. A. (2005). A motivational perspective on the relation between mental effort and performance: Optimizing learner involvement in instruction. *Educational Technology Research and Development, 53*(3), 25-34. doi:10.1007/BF02504795

Pannebakker, M. M., Band, G. P., & Ridderinkhof, K. R. (2009). Operation compatibility: A neglected contribution to dual-task costs. *Journal of Experimental Psychology: Human Perception and Performance, 35*(2), 447. doi:10.1037/a0013029

Park, S., Kim, M. S., & Chun, M. M. (2007). Concurrent working memory load can facilitate selective attention: evidence for specialized load. *Journal of Experimental Psychology: Human Perception and Performance, 33*(5), 1062. doi:10.1037/0096-1523.33.5.1062

Pastore, R. (2012). The effects of time-compressed instruction and redundancy on learning and learners' perceptions of cognitive load. *Computers & Education, 58*(1), 641-651. doi:10.1016/j.compedu.2011.09.018

Pastore, R. S. (2010). The effects of diagrams and time-compressed instruction on learning and learners' perceptions of cognitive load. *Educational Technology Research and Development, 58*(5), 485-505. doi:10.1007/s11423-009-9145-6

Perez-Moreno, E., Conchillo, A., & Recarte, M. A. (2011). The role of mental load in inattentional blindness. *Psicologica: International Journal of Methodology and Experimental Psychology, 32*(2), 255-278.

Perfect, T. J., Andrade, J., & Eagan, I. (2011). Eye closure reduces the cross-modal memory impairment caused by auditory distraction. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(4), 1008-1013. doi:10.1037/a0022930

Piquado, T., Isaacowitz, D., & Wingfield, A. (2010). Pupillometry as a measure of cognitive effort in younger and older adults. *Psychophysiology, 47*(3), 560-569. doi:10.1111/j.1469-8986.2009.00947.x

Pociask, F. D., & Morrison, G. (2004). The effects of split-attention and redundancy on cognitive load when learning cognitive and psychomotor tasks. *Association for Educational Communications and Technology, 2004 Annual Proceedings-Chicago: Volume #1*, 707-718.

Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction, 12*(1), 61-86. doi:10.1016/S0959-4752(01)00016-0

Porter, G., Troscianko, T., & Gilchrist, I. D. (2007). Effort during visual search and counting: Insights from pupillometry. *The Quarterly Journal of Experimental Psychology, 60*(2), 211-229. doi:10.1080/17470210600673818

Protopsaltis, A. (2008). Reading strategies in hypertexts and factors influencing hyperlink selection. *Journal of Educational Multimedia and Hypermedia, 17*(2), 191-213.

Purnell, K. N., Solman, R. T., & Sweller, J. (1991). The effects of technical illustrations on cognitive load. *Instructional Science, 20*(5-6), 443-462. doi:10.1007/BF00116358

Redding, G. M., Rader, S. D., & Lucas, D. R. (1992). Cognitive load and prism adaptation. *Journal of Motor Behavior, 24*(3), 238-246. doi:10.1080/00222895.1992.9941619

Redondo, M., & Del Valle-Inclan, F. (1992). Decrements in heart rate variability during memory search. *International Journal of Psychophysiology, 13*(1), 29-35. doi:10.1016/0167-8760(92)90017-6

Rey, G. D., & Buchwald, F. (2011). The expertise reversal effect: cognitive load and motivational explanations. *Journal of Experimental Psychology: Applied, 17*(1), 33-48. doi:10.1037/a0022243

Richter, P., Wagner, T., Heger, R., & Weise, G. (1998). Psychophysiological analysis of mental load during driving on rural roads-a quasi-experimental field study. *Ergonomics, 41*(5), 593-609. doi:10.1080/001401398186775

Rissman, J., Gazzaley, A., & D'Esposito, M. (2009). The effect of non-visual working memory load on top-down modulation of visual processing. *Neuropsychologia, 47*(7), 1637-1646. doi:10.1016/j.neuropsychologia.2009.01.036

Rizzardo, C. A., Colle, H. A., McGregor, E. A., & Wylie, D. (2013). Using a single map display both for navigational planning and for turn-by-turn vehicle guidance: Configural spatial knowledge acquisition. *Journal of Experimental Psychology: Applied, 19*(4), 301-319. doi:10.1037/a0034622

Roberts, W., Milich, R., & Fillmore, M. T. (2012). Constraints on information processing capacity in adults with ADHD. *Neuropsychology, 26*(6), 695. doi:10.1037/a0030296

Roelle, J., & Berthold, K. (2013). The expertise reversal effect in prompting focused processing of instructional explanations. *Instructional Science, 41*(4), 635-656. doi:10.1007/s11251-012-9247-0

Rosch, J.L. & Vogel-Walcutt, J.J. (2013). A review of eye-tracking applications as tools for training. *Cognition, Technology & Work, 15*, 313-327. doi:10.1007/s10111-012-0234-7

Roscoe, A. H. (1993). Heart rate as a psychophysiological measure for in-flight workload assessment. *Ergonomics, 36*(9), 1055-1062. doi:10.1080/00140139308967977

Rosenthal, R., & DiMatteo, M. R. (2001) Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology, 52*, 59-82. doi:10.1146/annurev.psych.52.1.59

Ross, V., Jongen, E. M., Wang, W., Brijs, T., Brijs, K., Ruiter, R. A., & Wets, G. (2014). Investigating the influence of working memory capacity when driving behavior is combined with cognitive load: An LCT study of young novice drivers. *Accident Analysis & Prevention, 62*, 377-387. doi:10.1016/j.aap.2013.06.032

Rubio, S., Díaz, E., Martín, J., & Puente, J. M. (2004). Evaluation of subjective mental workload: A comparison of SWAT, NASA-TLX, and workload profile methods. *Applied Psychology, 53*(1), 61-86. doi:10.1111/j.1464-0597.2004.00161.x

Ryan, A. M. (2003). Relations among multiple mental workload measures collected concurrently during a memory task (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3074252)

Salden, R. J., Paas, F., & van Merriënboer, J. J. (2001). Selection of learning tasks based on performance and cognitive load scores as a way to optimize the learning process. In: *Annual Proceedings of Selected Research and Development [and] Practice Papers Presented at the National Convention of the Association for Educational Communications and Technology*, Atlanta, GA.

Salden, R. J., Paas, F., Broers, N. J., & Van Merriënboer, J. J. (2004). Mental effort and performance as determinants for the dynamic selection of learning tasks in air traffic control training. *Instructional science, 32*(1-2), 153-172. doi:10.1023/B:TRUC.0000021814.03996.ff

Sammer, G. (1998). Heart period variability and respiratory changes associated with physical and mental load: Non-linear analysis. *Ergonomics, 41*(5), 746-755. doi:10.1080/001401398186892

Sanford, J. D. (2001). A cognitive load scale for measuring information management on the general aviation flight deck (Doctoral dissertation). Available from ProQuest Information & Learning. (UMI No. 9994931)

Savage, S. W., Potter, D. D., & Tatler, B. W. (2013). Does preoccupation impair hazard perception? A simultaneous EEG and eye tracking study. *Transportation Research Part F: Traffic Psychology and Behaviour, 17*, 52-62. doi:10.1016/j.trf.2012.10.002

Sawicka, A. (2008). Dynamics of cognitive load theory: A model-based approach. *Computers in human behavior, 24*(3), 1041-1066. doi:10.1016/j.chb.2007.03.007

Schafer, J. L. (1999) Multiple imputation: A primer. *Statistical Methods in Medicine, 8*(1): 3–15. doi:10.1177/096228029900800102

Schapkin, S. A., Freude, G., Gajewski, P. D., Wild-Wall, N., & Falkenstein, M. (2012). Effects of working memory load on performance and cardiovascular activity in younger and older workers. *International Journal of Behavioral Medicine, 19*(3), 359-371. doi:10.1007/s12529-011-9181-6

Scharfenberg, F. J., & Bogner, F. X. (2010). Instructional efficiency of changing cognitive load in an out-of-school laboratory. *International Journal of Science Education, 32*(6), 829-844. doi:10.1080/09500690902948862

Scheiter, K., Gerjets, P., Vollmann, B., & Catrambone, R. (2009). The impact of learner characteristics on information utilization strategies, cognitive load experienced, and performance in hypermedia learning. *Learning and Instruction, 19*(5), 387-401. doi:10.1016/j.learninstruc.2009.02.004

Schellekens, J. M., Sijtsma, G. J., Vegter, E., & Meijman, T. F. (2000). Immediate and delayed after-effects of long lasting mentally demanding work. *Biological Psychology*, *53*(1), 37-56. doi:10.1016/S0301-0511(00)00039-9

Schluroff, M. (1982). Pupil responses to grammatical complexity of sentences. *Brain and Language*, *17*(1), 133-145. doi:10.1016/0093-934X(82)90010-4

Schmidt-Weigand, F., & Scheiter, K. (2011). The role of spatial descriptions in learning from multimedia. *Computers in Human Behavior, 27*(1), 22-28. doi:10.1016/j.chb.2010.05.007

Schmutz, P., Heinz, S., Métrailler, Y., & Opwis, K. (2009) Cognitive load in ecommerce applications - measurement and effects on user satisfaction. *Advances in Human-Computer Interaction, 2009,* 1-9. doi:10.1155/2009/121494

Schnotz, W., & Kürschner, C. (2007). A reconsideration of cognitive load theory. *Educational Psychology Review*, *19*(4), 469-508. doi:10.1007/s10648-007-9053-4

Schnotz, W., & Rasch, T. (2005). Enabling, facilitating, and inhibiting effects of animations in multimedia learning: Why reduction of cognitive load can have negative results on learning. *Educational Technology Research and Development*, *53*(3), 47-58. doi:10.1007/BF02504797

Schoor, C., Bannert, M., & Brünken, R. (2012). Role of dual task design when measuring cognitive load during multimedia learning. *Educational Technology Research and Development, 60*(5), 753-768. doi:10.1007/s11423-012-9251-8

Schrader, C., & Bastiaens, T. (2012). Learning in educational computer games for novices: The impact of support provision types on virtual presence, cognitive load, and learning outcomes. *The International Review of Research in Open and Distance Learning, 13*(3), 206-227.

Schwamborn, A., Thillmann, H., Opfermann, M., & Leutner, D. (2011). Cognitive load and instructionally supported learning with provided and learner-generated visualizations. *Computers in Human Behavior, 27*(1), 89-93. doi:10.1016/j.chb.2010.05.028

Scott, B. M., & Schwartz, N. H. (2007). Navigational spatial displays: The role of metacognition as cognitive load. *Learning and Instruction*, *17*(1), 89-105. doi:10.1016/j.learninstruc.2006.11.008

Seibt, R., Scheuch, K., & Hinz, A. (2001). Reproducibility of cardiovascular responses to mental and static tasks. *Stress and Health*, *17*(4), 245-252. doi:10.1002/smi.903

Seufert, T., Jänen, I., & Brünken, R. (2007). The impact of intrinsic cognitive load on the effectiveness of graphical help for coherence formation. *Computers in Human Behavior, 23*(3), 1055-1071. doi:10.1016/j.chb.2006.10.002

Shallice, T., McLeod, P., & Lewis, K. (1985). Isolating cognitive modules with the dual-task paradigm: Are speech perception and production separate processes? *The Quarterly Journal of Experimental Psychology*, *37*(4), 507-532. doi:10.1080/14640748508400917

Sharek, D. J. (2014). Investigating real-time predictors of engagement: Implications for adaptive video games and online training (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3538299)

Sharit, J., & Salvendy, G. (1982). External and internal attentional environments II.

Reconsideration of the relationship between sinus arrhythmia and information load. *Ergonomics, 25*(2), 121-132. doi:10.1080/00140138208924932

Shepherd, C. E., & Bolliger, D. U. (2011). The effects of electronic portfolio tools on online students' perceived support and cognitive load. *The Internet and Higher Education, 14*(3), 142-149. doi:10.1016/j.iheduc.2011.01.002

Siegle, G. J., Ichikawa, N., & Steinhauer, S. (2008). Blink before and after you think: blinks occur prior to and following cognitive load indexed by pupillary responses. *Psychophysiology, 45*(5), 679-687. doi:10.1111/j.1469-8986.2008.00681.x

Siegle, G. J., Steinhauer, S. R., & Thase, M. E. (2004). Pupillary assessment and computational modeling of the Stroop task in depression. *International Journal of Psychophysiology, 52*(1), 63-76. doi:10.1016/j.ijpsycho.2003.12.010

Simmering, L. (2012). Deception detection: Using eye-tracking technology to measure faking in a simulated applicant setting (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3533098)

Stankus, A. I. (1994). Changes in the wave structure of cardiac rhythm under information load. *Human Physiology, 20*(2), 88-91.

Steidtmann, D., Ingram, R. E., & Siegle, G. J. (2010). Pupil response to negative emotional information in individuals at risk for depression. *Cognition and Emotion, 24*(3), 480-496. doi:10.1080/02699930902738897

Steinhauer, S. R., Condray, R., & Kasparek, A. (2000). Cognitive modulation of midbrain function: Task-induced reduction of the pupillary light reflex. *International Journal of Psychophysiology, 39*(1), 21-30. doi:10.1016/S0167-8760(00)00119-7

Stemler, Steven E. (2004). A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability. *Practical Assessment, Research & Evaluation, 9*(4). Retrieved from http://PAREonline.net/getvn.asp?v=9&n=4

Stevens, C. J., Gibert, G., Leung, Y., & Zhang, Z. (2013). Evaluating a synthetic talking head using a dual task: Modality effects on speech understanding and cognitive load. *International Journal of Human-Computer Studies, 71*(4), 440-454. doi:10.1016/j.ijhcs.2012.12.003

Streufert, S., Streufert, S. C., & Denson, A. L. (1983). Information load stress, risk taking, and physiological responsivity in a visual-motor task. *Journal of Applied Social Psychology, 13*(2), 145-163. doi:10.1111/j.1559-1816.1983.tb02327.x

Stuiver, A., Brookhuis, K. A., de Waard, D., & Mulder, B. (2014). Short-term cardiovascular measures for driver support: Increasing sensitivity for detecting changes in mental workload. *International Journal of Psychophysiology, 92*(1), 35-41. doi:10.1016/j.ijpsycho.2014.01.010

Swaak, J., & De Jong, T. (2001). Learner vs. system control in using online support for simulation-based discovery learning. *Learning Environments Research, 4*(3), 217-241. doi:10.1023/A:1014434804876

Swaak, J., van Joolingen, W., & de Jong, T. (1996). *Support for simulation-based learning: The effects of model progression on learning about oscillatory motion*. Netherlands: Center for Applied Research on Education.

Swallow, K. M., & Jiang, Y. V. (2014). Perceptual load and attentional boost: A study of their interaction. *Journal of Experimental Psychology: Human Perception and Performance, 40*(3), 1034. doi:10.1037/a0035312

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*, 257-285.

Sweller, J. (1994) Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), *295-312*. doi:10.1016/0959-4752(94)90003-5

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review, 22*(2), 123-138. doi:10.1007/s10648-010-9128-5

Sweller, J., Ayres, P., & Kalyuga S. (2011). *Cognitive load theory.* New York: Springer.

Sweller, J. & Chandler, P. (1991). Evidence for cognitive load theory. *Cognition and Instruction, 8*(4), 351-362.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*(3), 185-233.

Sweller, J., Van Merriënboer, J.J., & Paas, F.G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296.

Tasir, Z., & Pin, O. C. (2012). Trainee teachers' mental effort in learning spreadsheet through self-instructional module based on Cognitive Load Theory. *Computers & Education, 59*(2), 449-465. doi:10.1016/j.compedu.2012.01.009

Tattersall, A. J., & Foord, P. S. (1996). An experimental evaluation of instantaneous selfassessment as a measure of workload. *Ergonomics, 39*(5), 740-748. doi:10.1080/00140139608964495

Tattersall, A. J., & Hockey, G. R. J. (1995). Level of operator control and changes in heart rate variability during simulated flight maintenance. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 37*(4), 682-698. doi:10.1518/001872095778995517

Teigen, K. (1994). Yerkes-Dodson: A law for all seasons. *Theory & Psychology, 4*(4), 525-547. doi:10.1177/0959354394044004

Tichon, J. G., Mavin, T., Wallis, G., Visser, T. A., & Riek, S. (2014). Using pupillometry and electromyography to track positive and negative affect during flight simulation. *Aviation Psychology and Applied Human Factors, 4*(1), 23-32. doi:10.1027/2192-0923/a000052

Tsujii, T., & Watanabe, S. (2009). Neural correlates of dual-task effect on belief-bias syllogistic reasoning: a near-infrared spectroscopy study. *Brain Research, 1287*, 118-125. doi:10.1016/j.brainres.2009.06.080

Tulen, J. H. M., Van de Wetering, B. J. M., & Boomsma, F. (1998). Autonomic regulation during rest and mental load in Gilles de la Tourette syndrome. *Psychological Reports, 83*(2), 515-529. doi:10.2466/pr0.1998.83.2.515

Tuovinen, J.E. & Paas, F. (2004). Exploring multidimensional approaches to the efficiency of instructional conditions. *Instructional Science, 32*, 133-152. doi:10.1023/B:TRUC.0000021813.24669.62

Uysal, M. P. (2013). Towards the use of a novel method: The first experiences on measuring the cognitive load of learned programming skills. *Turkish Online Journal of Distance Education, 14*(1), 166-184.

Vandenbossche, J., Deroost, N., Soetens, E., Coomans, D., Spildooren, J., Vercruysse, S., Nieuwboer, A., & Kerckhofs, E. (2013). Impaired implicit sequence learning in Parkinson's disease patients with freezing of gait. *Neuropsychology, 27*(1), 28. doi:10.1037/a0031278

Van Gerven, P. W., Paas, F. G., Van Merriënboer, J. J., &Schmidt, H. G. (2002). Cognitive load theory and aging: Effects of worked examples on training efficiency. *Learning and Instruction, 12*, 87-105. doi:10.1016/S0959-4752(01)00017-2

Van Gerven, P. W., Paas, F., Van Merriënboer, J. J., & Schmidt, H. G. (2004). Memory load and the cognitive pupillary response in aging. *Psychophysiology, 41*(2), 167-174. doi:10.1111/j.1469-8986.2003.00148.x

Van Gerven, P. W., Paas, F., Van Merriënboer, J. J., & Schmidt, H. G. (2006). Modality and variability as factors in training the elderly. *Applied cognitive psychology, 20*(3), 311-320.

Van Gog, T., Ericsson, K. A., Rikers, R. M., & Paas, F. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology Research and Development, 53*(3), 73-81. doi:10.1007/BF02504799

Van Gog, T., Kester, L., & Paas, F. (2011). Effects of concurrent monitoring on cognitive load and performance as a function of task complexity. *Applied Cognitive Psychology, 25*(4), 584-587. doi:10.1002/acp.1726

Van Gog, T., Kirschner, F., Kester, L., & Paas, F. (2012). Timing and frequency of mental effort measurement: Evidence in favour of repeated measures. *Applied Cognitive Psychology, 26*(6), 833-839. doi: 10.1002/acp.2883

Van Gog, T., & Paas, F. (2008) Instructional efficiency: Revisiting the original construct in educational research. *Educational Psychologist, 43*(1), 16-26. doi:10.1080/00461520701756248

Van Gog, T., Paas, F., Sweller, J. (2010). Cognitive load theory: Advances in research on worked examples, animations, and cognitive load measurement. *Educational Psychological Review, 22*, 375-378. doi:10.1007/s10648-010-9145-4

Van Loon-Hillen, N., Van Gog, T., & Brand-Gruwel, S. (2012). Effects of worked examples in a primary school mathematics curriculum. *Interactive Learning Environmenta, 20*(1), 89-99. doi:10.1080/10494821003755510

Van Merriënboer, J. J. G., Schuurman, J. G., De Croock, M. B. M., & Paas, F. G. W. C. (2002). Redirecting learners' attention during training: Effects on cognitive load, transfer test performance and training efficiency. *Learning and Instruction, 12*(1), 11-37. doi:10.1016/S0959-4752(01)00020-2

Van Merriënboer, J. J. G., & Sweller, J. (2005) Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*(2), 147-177. doi:10.1007/s10648-005-3951-0

Van Orden, K. F., Limbert, W., Makeig, S., & Jung, T. P. (2001). Eye activity correlates of workload during a visuospatial memory task. *Human Factors: The Journal of* *the Human Factors and Ergonomics Society*, *43*(1), 111-121. doi:10.1518/001872001775992570

Van Zundert, M. J., Könings, K. D., Sluijsmans, D. M. A., & Van Merriënboer, J. J. G. (2012). Teaching domain-specific skills before peer assessment skills is superior to teaching them simultaneously. *Educational Studies, 38*(5), 541-557. doi:10.1080/03055698.2012.654920

Veltman, J. A., & Gaillard, A. W. K. (1996). Physiological indices of workload in a simulated flight task. *Biological Psychology*, *42*, 323-342.

Verney, S. P., Granholm, E., & Dionisio, D. P. (2001). Pupillary responses and processing resources on the visual backward masking task. *Psychophysiology*, *38*(1), 76-83. doi:10.1111/1469-8986.3810076

Vicente, K. J., Thornton, D. C., & Moray, N. (1987). Spectral analysis of sinus arrhythmia: A measure of mental effort. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *29*(2), 171-182. doi:10.1177/001872088702900205

Vytal, K., Cornwell, B., Arkin, N., & Grillon, C. (2012). Describing the interplay between anxiety and cognition: from impaired performance under low cognitive load to reduced anxiety under high load. *Psychophysiology, 49*(6), 842-852. doi:10.1111/j.1469-8986.2012.01358.x

Wallen, E., Plass, J. L., & Brünken, R. (2005). The function of annotations in the comprehension of scientific texts: Cognitive load effects and the impact of verbal ability. *Educational Technology Research and Development*, *53*(3), 59-71. doi:10.1007/BF02504798

Wetherell, A. (1981). The efficacy of some auditory–vocal subsidiary tasks as measures of the mental load on male and female drivers. *Ergonomics*, *24*(3), 197-214. doi:10.1080/00140138108559234

Whelan, R. (2007). Neuroimaging of cognitive load in instructional multimedia. *Educational Research Review*, *2*, 1-12. doi:10.1016/j.edurev.2006.11.001

Wiebe, E., & Annetta, L. (2008). Influences on visual attentional distribution in multimedia instruction. *Journal of Educational Multimedia and Hypermedia, 17*(2), 259-277.

Wiebe, E. N., Roberts, E., & Behrend, T. S. (2010). An examination of two mental workload measurement approaches to understanding multimedia learning.

Computers in Human Behavior, *26*(3), 474-481. doi:10.1016/j.chb.2009.12.006

Wieland-Eckelmann, R., Kleinbeck, U., Schwarz, R., & Häcker, H. (1989). The assessment of mental workload in dual-task performance: Task-specific and task-unspecific influences. *Recent developments in job analysis; Proceedings of the international symposium on job analysis, 1*, 237-251.

Wilkes, S. F. (2009). The effects of communication modality on presence, cognitive load and retention in Second Life (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3405113)

Williams, C. C., & Pollatsek, A. (2007). Searching for an O in an array of Cs: Eye movements track moment-to-moment processing in visual search. *Perception & Psychophysics, 69*(3), 372-381. doi:10.3758/BF03193758

Wilson, G. F. (2002). An analysis of mental workload in pilots during flight using multiple psychophysiological measures. *The International Journal of Aviation Psychology, 12*(1), 3-18. doi:10.1207/S15327108IJAP1201_2

Wirth, J., Künsting, J., & Leutner, D. (2009). The impact of goal specificity and goal type on learning outcome and cognitive load. *Computers in Human Behavior, 25*(2), 299-305. doi:10.1016/j.chb.2008.12.004

Wong, A., Leahy, W., Marcus, N., & Sweller, J. (2012). Cognitive load theory, the transient information effect and e-learning. *Learning and Instruction*, *22*(6), 449-457. doi:10.1016/j.learninstruc.2012.05.004

Wong, A., Marcus, N., Ayres, P., Smith, L., Cooper, G. A., Paas, F., & Sweller, J. (2009). Instructional animations can be superior to statics when learning human motor skills. *Computers in Human Behavior, 25*(2), 339-347. doi:10.1016/j.chb.2008.12.012

Worthy, D. A., Otto, A. R., & Maddox, W. T. (2012). Working-memory load and temporal myopia in dynamic decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*(6), 1640. doi:10.1037/a0028146

Xie, B., & Salvendy, G. (2000). Prediction of mental workload in single and multiple task environments. *International Journal of Cognitive Ergonomics, 4*(3), 213-242. doi:10.1207/S15327566IJCE0403_3

Xing, C., & Isaacowitz, D. (2011). Age differences in attention toward decision-relevant information: education matters. *International Journal of Aging and Human*

Development, 73(4), 299-312.

Yao, Y., & Gill, M. (2009). The effect of hypertext annotation presentation formats on perceived cognitive load and learner control. *Journal of Interactive Learning Research, 20*(3), 359-373.

Yeh, T. K., Tseng, K. Y., Cho, C. W., Barufaldi, J. P., Lin, M. S., & Chang, C. Y. (2012). Exploring the impact of prior knowledge and appropriate feedback on students' perceived cognitive load and learning outcomes: Animation-based earthquakes instruction. *International Journal of Science Education, 34*(10), 1555-1570. doi:10.1080/09500693.2011.579640

Yeung, A. S. (1999). Cognitive load and learner expertise: Split-attention and redundancy effects in reading comprehension tasks with vocabulary definitions. *The Journal of Experimental Education, 67*(3), 197-217. doi:10.1080/00220979909598353

Yeung, A. S., Jin, P., & Sweller, J. (1998). Cognitive load and learner expertise: Split-attention and redundancy effects in reading with explanatory notes. *Contemporary Educational Psychology, 23*(1), 1-21. doi:10.1006/ceps.1997.0951

Yeung, A. S., Lee, C. F. K., Pena, I. M., & Ryde, J. (2000). *Toward a Subjective Mental Workload Measure*. Paper presented at the International Congress for School Effectiveness and Improvement, Hong Kong, China.

Yusoff, N. M., & Salim, S. S. (2012). Investigating cognitive task difficulties and expert skills in e-Learning storyboards using a cognitive task analysis technique. *Computers & Education, 58*(1), 652-665. doi:10.1016/j.compedu.2011.09.009

Yoon, J. O., & Kim, M. (2011). The effects of captions on deaf students' content comprehension, cognitive load, and motivation in online learning. *American Annals of the Deaf, 156*(3), 283-289. doi:10.1353/aad.2011.0026

Zekveld, A. A., & Kramer, S. E. (2014). Cognitive processing load across a wide range of listening conditions: Insights from pupillometry. *Psychophysiology, 51*(3), 277-284. doi:10.1111/psyp.12151

Zhang, L., Ayres, P., & Chan, K. (2011). Examining different types of collaborative learning in a complex computer-based environment: A cognitive load approach. *Computers in Human Behavior, 27*(1), 94-98. doi:10.1016/j.chb.2010.03.038

Zheng, R., & Cook, A. (2012). Solving complex problems: A convergent approach to cognitive load measurement. *British Journal of Educational Technology, 43*(2), 233-246. doi:10.1111/j.1467-8535.2010.01169.x

Zheng, R., McAlack, M., Wilmes, B., Kohler-Evans, P., & Williamson, J. (2009). Effects of multimedia on cognitive load, self-efficacy, and multiple rule-based problem solving. *British Journal of Educational Technology, 40*(5), 790-803. doi:10.1111/j.1467-8535.2008.00859.x

Zheng, R., Miller, S., Snelbecker, G. & Cohen, I. (2006). Use of multimedia for problem-solving tasks. *Journal of Technology, Instruction Cognition and Learning*, *3*(1–2), 135–143.

Zumbach, J., & Mohraz, M. (2008). Cognitive load in hypermedia reading comprehension: Influence of text type and linearity. *Computers in Human Behavior, 24*(3), 875-887. doi:10.1016/j.chb.2007.02.015